SUBSTANCES HAZARDOUS TO HEALTH - THE NATURE OF THE EXPERTISE ASSOCIATED WITH COMPETENT RISK ASSESSMENT

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Summary

This research investigated expertise in hazardous substance risk assessment (HSRA). Competent pro-active risk assessment is needed to prevent occupational ill-health caused by hazardous substance exposure occurring in the future. In recent years there has been a strong demand for HSRA expertise and a shortage of expert practitioners.

The discipline of Occupational Hygiene was identified as the key repository of knowledge and skills for HSRA and one objective of this research was to develop a method to elicit this expertise from experienced occupational hygienists.

In the study of generic expertise, many methods of knowledge elicitation (KE) have been investigated, since this has been relevant to the development of 'expert systems' (thinking computers). Here, knowledge needed to be elicited from human experts and this stage was often a bottleneck in system development, since experts could not explain the basis of their expertise.

The methodology used in this study involved several KE techniques including, exploratory interviews, focused discussion using case-studies, risk assessment visits and a novel videotape KE method. (The views expressed by the occupational hygienists in the interviews reported here, do not necessarily represent those of the author, nor possibly their own considered view when faced with a real situation.)

This latter procedure was developed to investigate HSRA expertise in a study where participants carried out a risk assessment exercise. Initial case-study information was presented on videotape and further data to complete the task, had to be obtained from the 'factory manager' (role-played by the author). The consultation was recorded on audio-tape and with the production of written transcripts for analysis. Following a pilot study using a small number of participants, the method was used, with some modification, in the larger main study.

At an intermediate stage, information collected was used to structure a basic model of hazardous substance risk assessment activity (HSRA Model B) and this formed the basis of tape transcript analysis in the main study with derivation of a 'classification' and a 'performance matrix'. The study aimed to elicit the expertise of occupational hygienists and compare their performance with other health and safety professionals (occupational health physicians, occupational health nurses, health and safety practitioners and trainee health and safety inspectors), as evaluated using the matrix.

As a group, the hygienists performed best in the exercise, and this group were particularly good at process elicitation and at recommending specific control measures, although the other groups also performed well in selected aspects of the matrix and the work provided useful findings and insights.

From the research, two models of HSRA have been derived, an HSRA aid, together with a novel videotape KE technique and interesting research findings. The implications of this are discussed with respect to future training of HS professionals and wider application of the videotape KE method.

KEY WORDS

Dedication

to Rohan

and Betty and Bobby

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Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
ACTS	Advisory Committee on Toxic Substances (HSC)
AI	Artificial Intelligence
AIHA	American Industrial Hygiene Association
BOHS	British Occupational Hygiene Society
BERBOH	British Examining and Registration Board in Occupational Hygiene
BEBOH	British Examining Board in Occupational Hygiene
CHIP	Chemicals (Hazard Information and Packaging) Regulations
CIH	Certified Industrial Hygienist (USA)
COSHH	Control of Substances Hazardous to Health Regulations 1994
EINECS	European Inventory of Existing Commercial Substances
GF	Glass Fibre
GRP	Glass Reinforced Plastic
GOPOH	Group of Practising Occupational Hygienists
HDS	Hazard Data Sheet
HSC (UK)	Health and Safety Commission
HSE (UK)	Health and Safety Executive
HSI	Trainee Health and Safety Inspector
HSRA	Hazardous Substance Risk Assessment
HS	Health and Safety
KE	Knowledge Elicitation
IOH	Institute of Occupational Hygienists
IOSH	Institute of Occupational Safety and Health
LEV	Local Exhaust Ventilation
LFS	Labour Force Survey
MEL	Maximum Exposure Limit
MHSW	Management of Health and Safety at Work Regulations 1992
NIOSH	National Institute for Occupational Safety and Health (USA)
NONS	Notification of New Substances Regulations 1993
OES	Occupational Exposure Standard
OH	Occupational Hygienist
OHP	Occupational Health Physician
OHN	Occupational Health Nurse
RSP	Registered Safety Practitioner
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995
SME	Small- and Medium-sized Enterprise
SOM (UK)	Society of Occupational Medicine
SP	Safety Practitioner
TLV	Threshold Limit Value (ACGIH)

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Setting the scene – the occupational health problem and exposure to substances hazardous to health

"All substances are poisons, there is none that is not a poison, the right dose differentiates a poison and a remedy."

Paracelsus (1493-1541)

1.1 INTRODUCTION

Large quantities of hazardous substances are found and used in many industries. In virtually all workplaces people are to some extent exposed to them. Such exposures result in a large national occupational ill-health problem. For a range of reasons - including data collection systems, current medical training and practice, the multi-causal and/or chronic nature of some diseases – it is commonly difficult to link much 'community' ill-health with occupational factors. Therefore, one cannot rely solely on recognised occupational ill-health or relevant statistics to guide current approaches to toxic substance management. Indeed, some 'occupational' diseases will probably never be linked with workplace causes. Also, the clinical symptoms of some chronic occupational diseases may be the result of working conditions 10-20 years ago about which obviously nothing can now be done. The current challenge is to prevent chronic ill-health in 10-20 years time by competent, pro-active toxic substance risk management.

A point of departure for this research is that it is the professional occupational hygienist who is best equipped in terms of requisite knowledge and practical

skills to carry out this risk assessment and management task. The research examines how the risk assessment and management approach developed within occupational hygiene and then explores the nature of this expertise in order to identify what makes this distinctive. Other related professionals; occupational physicians, occupational health nurses, safety practitioners and enforcement inspectors have professional training in occupational hygiene principles and develop expertise in this area. A further objective of the research is to investigate the approach of these professionals in order *inter-alia* to identify relevant training needs.

The need of employers for hazardous substance risk assessment (HSRA) expertise is such that there are unlikely to be sufficient occupational hygienists to satisfy demand, and by necessity, much HSRA is carried out by line managers and others with limited knowledge and skills in this area. A key reason for eliciting HSRA expertise is for the development of risk assessment training and aids for such managers. There are some benefits when managers carry out HSRA within their own organisations. From a health and safety viewpoint it may encourage 'ownership' of toxic substance control by managers and prevent an expert dependency culture (and costs) resulting from the over-use of external consultants. It is believed that much of the work of 'primary' risk assessment can be carried out effectively by suitably trained and guided managers. One purpose of this research is to aid such training and support. 'Primary risk assessment' in this context refers to the collection of information on tasks, people exposed, substances used and effectiveness of control measures, in order to come to an initial conclusion on existing health risks. In addition, the expertise of primary risk assessors should enable them to recognise where a particular assessment situation is too complex and that further technical support is needed.

The introductory chapter opens with a discussion of current occupational health perspectives and problems, including the profound difficulty of having 'community' ill-health that cannot be linked with causative occupational factors and the fact that, for the great majority of substances currently used by industry, there is little toxicity data on chronic health hazards posed to exposed people. This discussion leads to an outline of the risk assessment and

management framework in the context of current legislation, with particular reference to the *Control of Substances Hazardous to Health Regulations 1994* (COSHH).

There is a review of the historical approach to toxic substance control and this highlights the inadequacy of the traditional reactive approach to toxic substance management. Furthermore, even where ill-health problems are recognised and clearly linked to causes, this does not necessarily mean that suitable action will be taken, since other political, economic and social factors may intervene. This reactive approach seen in the historical development of toxic substance legislation has now given way to modern risk assessment-driven legislation.

The fundamental standpoint of this research is that competent toxic substance risk assessment and management is required now to prevent chronic occupational ill-health in the future and there is a shortage in the availability of this expertise. The thrust of the thesis is that such expertise is possessed by occupational hygiene specialists and that this expertise may be studied and elicited in order to improve the competence of others who have to carry out this task.

This Chapter will explore the essential features of the UK's large occupational health problem of which a substantial component is chronic ill-health caused by exposure to toxic substances. However, it will be shown that the true picture is obscured by poor national occupational disease statistics. Various reasons are held to be responsible for this poor data, including the latency and multi-factorial nature of some disease. Although we do not know the magnitude of this ill-health problem we do know that if we can reduce exposures (and therefore 'dose') then we must be reducing levels of subsequent ill-health (even if we do not know by how much). The case will be made that pro-active hazardous substance risk assessment (HSRA) is needed now in order to reduce the risk of future chronic ill-health.

1.2 THE CURRENT OCCUPATIONAL HEALTH PROBLEM

The previous section demonstrated the dearth of competent occupational hygiene expertise available to carry out HSRA. The purpose of this section is to make clear that the occupational health problem continues to be very serious but most statistical evidence (discussed in detail below) is likely to underestimate the seriousness of the situation.

HSE (1994) estimated that there were 2.2 million people in Great Britain suffering ill-health caused or made worse by working conditions and, in total, work-related ill-health was estimated to cost the economy £4-5 billion annually.

It is generally believed that each year more people in Great Britain die from occupational diseases than are killed in industrial accidents. (For example, 272 workers died in accidents at work between April 1995 and March 1996 (HSE, 1996), whilst with occupationally-induced cancer alone, the HSE (1996) commented:

> "The existing routine sources of information on occupational cancer greatly underestimate its scale; and the best available estimate is that 4 per cent of cancer deaths have occupational causes, with a range of acceptable figures from 2 to 8 per cent, which would correspond to between 3000 and 12,000 deaths per year in Britain today."

There is no effective national system to identify and collect data on occupationally-induced disease. John Cullen's (Chairman's Foreword to HSC Annual Report 1989/90) statement below acknowledges the difficulty in collecting such data:

> "We can measure the extent of ill-health caused by work only quite roughly. Our current best estimate suggests that it directly gives rise to at least 2,000 premature deaths each year, and contributes to a further 8,000. We estimate that at least 80,000 new cases of work-related disease occur each year and that more than 500,000 people suffer continuing damage to health from work."

The question as to whether an accident happened at work is reasonably straightforward, whilst the judgement as to whether a particular illness was caused by work is often problematic. A major problem when considering ill-health and disease in the wider community is separating that proportion caused by work and that caused by other factors such as smoking, diet, life-

style and general environment. For example, lung cancer (carcinoma) is a common disease in the general population and is strongly linked to smoking.

However, occupational factors, such as exposure to chromates, arsenic and other agents, are also associated with an increased risk of this disease. In an individual case, adequate records may not be available to indicate occupational exposure to such toxic substances (assuming a doctor asks the right questions about work history) and therefore a connection with work may not be made. Also, other substances causing lung cancer and other common diseases have not yet been recognised and (Nicholson, 1984) comments:

> "Any plausible frequency distribution of the relative risks of site-specific human occupational cancers would certainly have a large number of points with relative risk less than 5 were they to be known. In terms of accepted human carcinogens we have clearly identified only the tip of the iceberg."

In the past, much recognised ill-health was acute in nature, ie, symptoms occurred within a relatively short period of exposure (often at a high level) to the toxic substance. This usually allowed the connection to be made between cause and effect and thus appropriate control measures could be identified and applied. With chronically-induced disease, exposures are generally at lower concentrations and long-term. The interval between first exposure and presentation of observable health effects may be up to 20-40 years in the case of some substances which cause cancer. People often have several jobs during their working lives or different occupations in the same industry. This results in complicated and varying patterns of exposure. With long latency periods, the multi-causal nature of some diseases (ie, different agents cause the same illness) and frequent poor record-keeping practice in the past, it is often difficult to make the connection between occupational cause and ill-health effect. Consequently, this makes it difficult to obtain accurate statistical estimates of the prevalence and incidence of current 'occupational' disease.

1.2.1 SOURCES OF NATIONAL OCCUPATIONAL HEALTH STATISTICS

The HSE publishes annual statistics on occupational disease, which fall into several major categories. HSE's stated policy is to make the fullest use of a

range of sources. Different sources give varying estimates of the extent and severity of work-related disease. Major statistical data sources are listed below:

- Industrial Injuries Scheme and 'Prescribed diseases' under social security legislation.
- Data collected from the *Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995* (RIDDOR). (These regulations superseded the 1985 RIDDOR Regulations.)
- Voluntary schemes for reporting work-related respiratory and skin disease operated by professional medical bodies.
- Household surveys giving estimates of the numbers of people who think they have ill-health caused or made worse by their work.
- Death certificates which are mainly useful for monitoring the most serious forms of occupational lung disease.

1.2.1.1 Industrial Injuries Scheme - Prescribed Diseases

These are diseases whose occupational cause is well established. Cases are individually confirmed by medical examination and checking of the person's work history. Typical numbers claiming 'Industrial Disablement Benefit' for selected diseases are given in Table 1.1 below. The scheme compensates people (or their dependants) who are killed or injured by an accident at work or who suffer from a 'Prescribed Disease'. Diseases are usually prescribed in connection with defined occupations or work activities. Disablement benefit is awarded to sufferers where their 'body or mind is impaired for more than 15 weeks', irrespective of whether the claimant is working or suffering loss of earnings.

Entitlement depends on a medical assessment of degree of disability suffered. The sufferer is compared to a healthy person of the same age and sex and their disability expressed as a percentage. Until 1986 benefit was paid where disability was recognised and accepted. This was payable (on a sliding scale)

irrespective of the actual level of impairment. At this point a new rule was introduced where for most prescribed diseases, benefit would only be payable if disability exceeded 14%. This change greatly reduced the number of people qualifying for benefit. Using prescribed disease A8 ("Inflammation of the tendons of the hand, forearm or associated tendon sheaths") as an example, qualifying cases fell from 390 (1984-85) to 4 (1986-87). In 1981, there were 2,275 'spells' of industrial injury benefit awarded for cases of this disease (HSE, 1985). In the case of Vibration White Finger (VWF), of the 5,401 assessed cases in 1990-91, only 31 had sufficient disability from VWF alone to receive benefit. Some may have reached the 14% threshold by aggregation of other disability - most likely in this case from occupational deafness.

Changes in the eligibility rules for benefit affect the numbers putting in a claim, ie, once people realise that a successful claim is unlikely, they are less likely to apply for assessment.

Therefore, one must be very cautious in interpreting social security data in terms of the national occupational disease picture. (The figure for 1990-91 represents a peak and in the year 1994-95, 1747 people were assessed for this benefit for VWF.)

Table 1-1 Claims for Industrial Disablement Benefit by Year

Industrial disease	*1984-85*	*1985-86*	*1986-87*[1]	*1987-88*	*1988-89*	*1989-90*	*1990-91*	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*
Occupational deafness	1,492	1,179	1,381	1,515	1,128	1,506	1,041	972	901	882	763	531
Dermatitis	619	785	464	368	285	301	432	411	419	392	368	328
Pneumoconiosis (& Byssinosis)	806	836	776	652	732	741	784	415	440	632	439	366
Tenosynovitis	390	619	376	322	294	423	556	649	911	800	787	548
VWF[2]	3	641	1,366	1673	1,056	2,601	5,401	2369	1447	1425	1747	3016
Asthma	166	166	220	222	220	216	293	553	510	506	514	410
Lung cancer (asbestos)	8	34	55	59	54	58	55	54	72	77	55	51
Lung cancer (non-asbestos					4	5	4	6	3	-	4	2

1. After 1986 figures represent new cases "assessed" for disablement as opposed to those actually receiving the benefit in the data listed before this time.

2. In 1994/1995 numbers were down to 1747 cases assessed for benefit for VWF.

Concerning lung cancer caused by asbestos or other hazardous substances the HSE (1996) has stated :

> "Exposure to asbestos is by far the most important known occupational cause of cancer, in terms of incident cases and mortality."

> "Because of the difficulty of determining the cause of individual cases, the numbers awarded disablement benefit considerably understate the likely true number, which is at least equal to the number of mesotheliomas and may be even greater."

1.2.1.2 Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR)

These Regulations define a list of 'reportable' diseases, placing a duty on the employer to inform the HSE (or other relevant authority) where cases occur. The list is very similar to the 'prescribed' disease list described above, though with notable omissions such as the common condition of occupational deafness. Dermatitis has been added to the list with the recent revision of the Regulations. Table 1.2 highlights the extent of the inadequacy of data collected by the RIDDOR system. The figures refer to total national reported cases of occupational disease. (HSE, 1996)

Table 1-2 Total cases of occupational disease reported under RIDDOR

Year	*Cases*
1986/87	276
1987/88	332
1988/89	310
1989/90	322
1990/91	309
1991/92	392
1992/93	329
1993/94	362
1994/95	508

There are many fundamental problems with the RIDDOR system resulting in grossly inadequate data collection. Although, the system has been marginally improved with the 1995 revised regulations, it is believed that it is

fundamentally flawed. Many factors contribute to this underreporting - people worry about loss of jobs, the onus for reporting is put on the employer and often the causes of ill-health are not identified. The reporting mechanism is complicated and cumbersome. However, this thesis is not the place to discuss this subject in detail. The RIDDOR system thus results in gross underreporting of occupational disease.

1.2.1.3 Labour Force Survey (LFS)

Some insight into overall levels of occupational disease may be gained from other sources. Hodgson *et al.* (1993) report on the 1990 Labour Force Survey (LFS), carried out by the Office of Population Censuses and Surveys (OPCS), where adult respondents in England and Wales were asked whether they had:

> "In the past 12 months suffered from any illness, disability, or other physical problem that was caused or made worse by (their) work? Please include any work you have done in the past."

Follow-up questions established the nature of the illness and the job that was thought to have caused it; whether work was thought to have caused the condition or to have simply made it worse and the number of sick leave days during the year due to the complaint. Based on the results of this survey, the following estimates of self-reported work-related illness have been published:

- an estimated 750,000 took 13 million days off in 1989/90 because of what they regarded as 'work-related illness';
- an estimated another 730,000 in work were affected but took no time-off;
- retired and unemployed people reported that they were affected by the long-term consequences of work.

On the basis of these figures, the HSE (1994) estimated the costs to the individuals affected, employers and to society at large. The types of ill-health are summarised in Figures 1.1 and 1.2, where results are presented as disease 'caused' by work together with those cases 'made worse'.

Figure 1.1 LFS – disease 'caused' by work

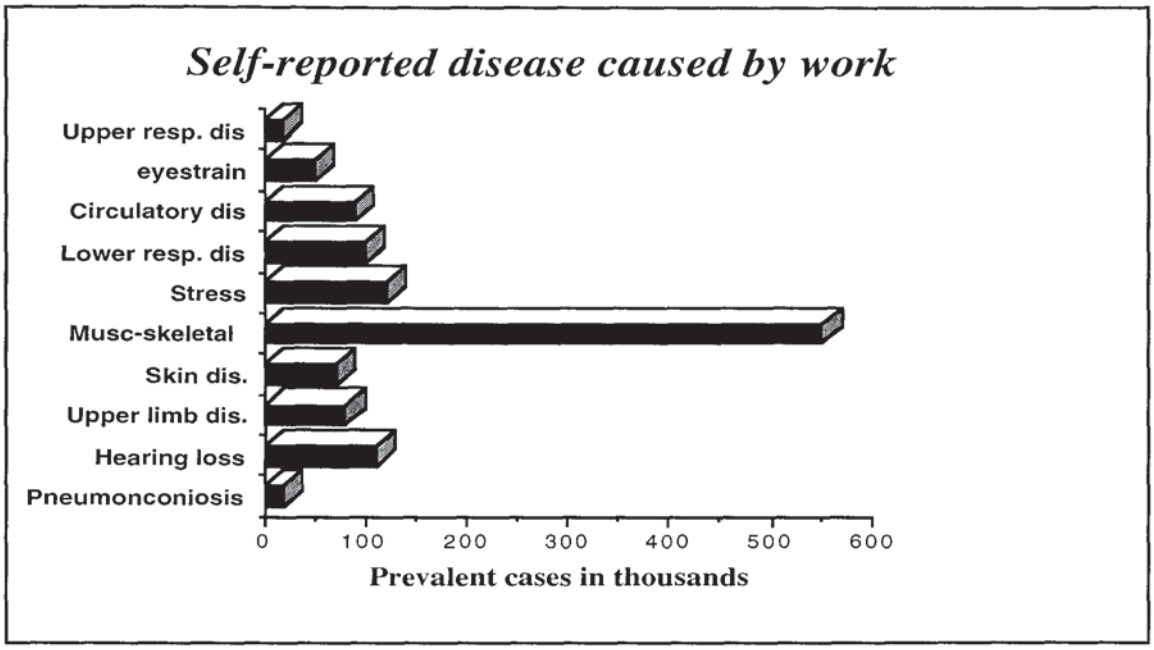
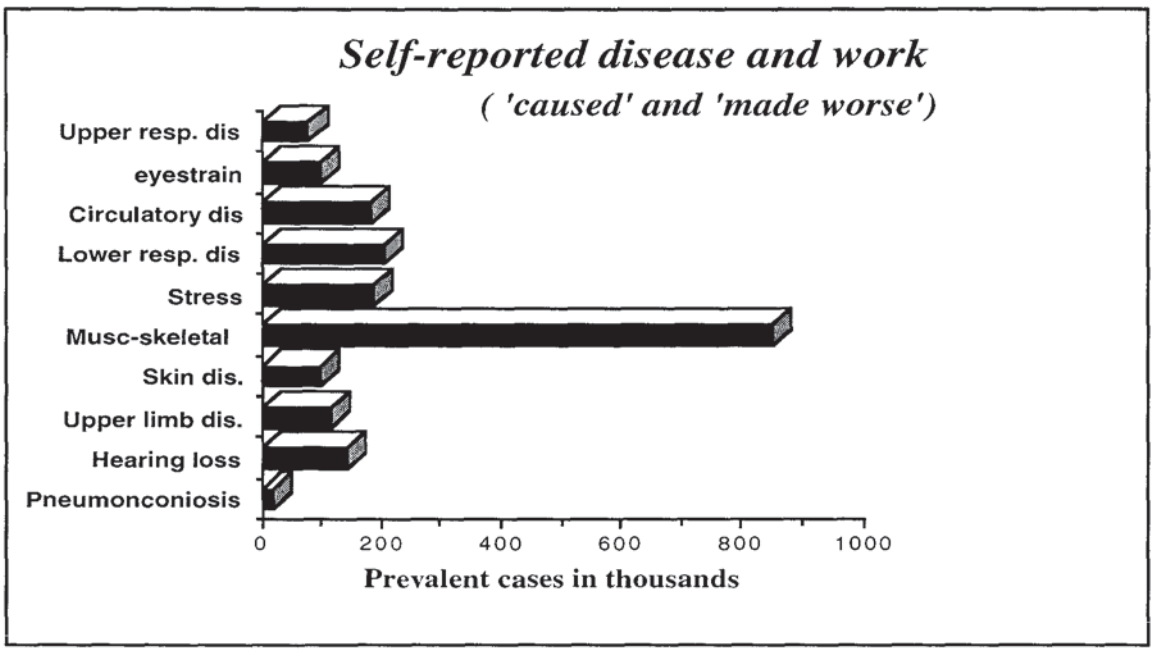


Figure 1.2 LFS disease – 'caused and made' worse by work



The numbers indicated in the LFS contrast starkly with information gathered from the traditional sources discussed earlier. The LFS estimates that around 7% of all General Practitioner (GP) consultations involve work-related ill-heath.

Following the implementation of the original 1985 RIDDOR code, the Health and Safety Commission asked its Medical Advisory Committee to develop proposals for a more comprehensive data collection system for occupational ill-

health. The Medical Advisory Committee produced a report (HSE, 1988) and argued for:

> "a general framework for occupational health advice and surveillance"

which would:

> "enable employers to report certain types of illness and to investigate and retain records of others."

Various measures were recommended including:

> "the encouragement of case registers for specific types of illness and disease related to occupation - doctors would be alerted to report particular diseases to a central body collecting information on that disease."

Only this latter recommendation has been put into practice. In 1989, the 'Surveillance of work-related respiratory disease' (SWORD) scheme was implemented at the London Chest Hospital. SWORD is a reporting system for cases of occupationally-related respiratory disease which have been seen for the first time by UK occupational and chest physicians.

Table 1-3 Cases of respiratory disease reported to SWORD (HSE, 1996)

Year	*Cases*
1992	1047
1993	912
1994	968
1995	851

In 1993, the University of Manchester (Centre for Occupational Health) set up a similar case register for work-related skin disease known as 'EPIDERM'. The following figures relate to new cases of diagnosed contact dermatitis:

Table 1-4 Cases of skin disease reported to EPIDERM (HSE, 1996)

Year	*Cases*
1993	1930
1994	1222
1995	1176

Figures from the SWORD and EPIDERM schemes demonstrate (regularly) that data from the Industrial Injuries Scheme (on respiratory and skin disease) underreport true levels of occupational ill-health.

1.3 CONCLUSION

Data from both RIDDOR and the Industrial Injuries Scheme underestimate true levels of ill-health caused by occupational factors. Further, it is unlikely that British statistical data on occupational ill-health will improve dramatically in the near future and this poor prognosis for the quality of occupational disease data makes it difficult to decide what share of national resources should be allocated to the prevention of occupational disease.

A useful approach would be to collect and examine data, that would serve as indirect indicators of occupational health performance. For example, data on the frequency and quality of risk assessments generated by the COSHH Regulations or the Noise at Work Regulations 1989, together with the adequacy of implemented control measures. Another data source that would improve the picture would be information from medical surveillance generated by such risk assessments. Where these indicators showed that 'occupational health' performance was improving, then this would suggest an impact on the underlying (if not wholly recognised) occupational disease burden.

The seriousness of the problem despite the weakness of much available data emphasises the importance of effective methods to reduce substantially exposure to hazardous substances at work. The next section explores the reasons why for many years inadequate steps were taken to reduce occupational exposure to hazardous substances.

1.4 HISTORICAL BACKGROUND AND PERSPECTIVES IN TOXIC SUBSTANCE MANAGEMENT

The aim of this section is to show the inadequacies of the traditional reactive approach to toxic substance control associated with previous weak legislation and its lack of enforcement together with the past focus on compensation for, rather than prevention of, occupational ill-health.

1.4.1 HISTORICAL BACKGROUND

Exposure to hazardous substances and consequent ill-health has long been a problem for people at work. People were subjected to 'occupational' health hazards long before the industrial revolution. In the Stone Age, the knapping of flints would have produced clouds of silica dust. However, it is unlikely that many of our ancestors would have died of silicosis due to the high prevalence of more immediate causes of death.

Mining has long been recognised as a hazardous occupation. However, in the earliest times miners tended to be slaves who were thought to be readily replaceable and thus there was no perceived need for mine owners to improve working conditions. Amongst the first recorded observations on miners and their diseases were those made by the physicians Agricola (1494-1555) and Paracelsus (1493-1541). In the Middle Ages the status of the miner changed from serf to skilled worker. The demand for currency required an increasing supply of gold and silver and consequently mines tended to be dug deeper and working conditions in general, worsened. Agricola described the prevailing diseases in mining communities and although levels of mortality from pulmonary diseases were not recorded nor causes known, these conditions would have included silicosis, tuberculosis and lung cancer (the latter due to exposure to radioactive ores). Mortality was high as indicated by this comment of Agricola (cited by Schilling, 1981):

> "in the mines of the Carpathian Mountains women are found who have married seven husbands, all of whom this terrible consumption has carried off to a premature death."

Paracelsus similarly recognised the diseases of the mining community:

> "we must have gold and silver, and also other metals, iron, tin, copper, lead and mercury. If we wish to have these we must risk both life and body in struggle with many enemies that oppose us."

Another physician Bernardino Ramazzini (1633-1714) published the first systematic study of trade diseases and recommended that physicians should always enquire about a patient's occupation. He advised against dusty work in confined spaces and commented on lack of ventilation in workplaces. Furthermore, he advised patients to stop work immediately the symptoms of disease appeared. In his book *De Morbis Artificium* (cited by Schilling, 1981) he described many occupational diseases from a range of occupations.

> "I hesitate and wonder whether I shall bring bile to the noses of doctors - they are so particular about being elegant and immaculate – if I invite them to leave the apothecary's shop which is usually redolent of cinnamon and where they linger as in their own domain, and to come to the latrines and observe the diseases of those who clean out the privies."

1.4.2 THE INDUSTRIAL REVOLUTION IN GREAT BRITAIN

In the late 18th century the Industrial Revolution began in Great Britain with the development of the factory system. The dreadful working conditions aroused concern about the effects of work on the health and well-being of workers.

In 1775, Percival Pott drew attention to soot as a cause of scrotal cancer in children working as chimney sweeps. This is the first example of a documented 'occupational' cancer. The condition was caused by irritation of the skin of the scrotum by chimney soot. (The actual cause was the carcinogenic action of the chemical 3,4 benzopyrene and related hydrocarbons.) Pott's original evocative comments are cited by Hunter (1976):

> "The fate of these people seems singularly hard: in their early infancy they are most frequently treated with great brutality, and almost starved with cold and hunger; they are thrust up narrow and sometimes hot chimneys, where they are bruised, burned and almost suffocated, and when they get to puberty become peculiarly liable to a most noisome, painful and fatal disease."

In 1773, the philanthropist Jonas Hanway drew attention to the miserable condition of the 'climbing boys' and suggested that such apprentices should be

licensed. In 1814, an Act was passed by Parliament forbidding the climbing of chimneys by children, but by the 1860s the employment of boys for this purpose was increasing. It was not until 1875, with the Bill of Lord Shaftesbury, that this practice was finally stopped (Hunter, 1976).

In 1831, the physician Charles Thackrah, published the seminal British work on occupational disease entitled: *"The Effects of the Principal Arts, Trades and Professions, and of Civic States and Habits of Living, on Health and Longevity, with Suggestions for the Removal of many of the Agents which produce Disease and shorten the duration of Life."* The work attracted the attention of both the medically-qualified and the layman when it appeared. Hunter (1976) credits it with stimulating factory and health legislation, which mitigated some of the worst effects of industrialisation. The book was extensively quoted by Michael Sadler in Parliament during the reading of the 1833 Factory Bill. Thackrah comments on many subjects including: postural deformities in young children, lung disease in tailors, miners, metal grinders and other groups and lead poisoning in pottery glaze-dippers. He made specific recommendations for eliminating lead poisoning in pottery workers:

> "Could not the process be effected without the immersion of the hands in the metallic solution? Or could it not be effected by a machine? Or could not some article less noxious be substituted for the lead? I am told that cheapness of the leaden glaze is the chief recommendation. The total disuse of lead in glaze is highly desirable."
>
> Thackrah cited by Hunter (1976)

Measurement of occupational mortality was first introduced into England and Wales in the middle of the 19th century. William Farr used population census figures to calculate mortality rates in certain occupations (Schilling, 1989). This drew attention to the high risks of injury and disease in factory workers and miners at the time. Greenham, compared the mortality figures of lead-mining towns with those towns without lead mines and concluded that there was excessive mortality due to inhalation exposure to lead dust (Schilling, 1989). From this work, he also came to the general conclusion that much pulmonary disease in the industrial districts of England and Wales was due to inhalation of dust and fumes arising at work. The first factory inspectors were appointed in 1833 against much opposition and with very limited powers, and it was not

until 1898 that the first medical inspector of factories (Sir Thomas Legge) was appointed. In 1862, the first Chief Medical Officer to the Local Government Board, Sir John Simon (who had been much influenced by Thackrah's work) commented:

> "The canker of industrial disease gnaws at the very root of our national strength."

Some pioneers for improved conditions occasionally inspired the hostility of both colleagues and manufacturers. The physician Arlidge (1822-99) studied the diseases of potters and a colleague wrote of him:

> "He made an unfortunate beginning of his career by compiling statistics of the people working in the potteries which gravely reflected on the humanity of the manufacturers. He was instrumental in the appointment of factory surgeons for earthenware and china manufacture upon which this entailed much expense. His medical friends were up against him and up to his death this feeling never died out."

In the mid-nineteenth century there was general concern about lead poisoning in particular in the pottery industry, where this overshadowed the much older problem of potter's rot or silicosis. Illustrating the problem of arousing concern about chronic ill-health conditions, Arlidge commented:

> "In one sense, indeed, it is unfortunate that it does not for the most part awake attention by any immediate tangible consequences. Its disabling action is very slow but it is ever progressive, and until it has already worked its results it is let pass as a matter indifference - an inconvenience of the trade."
>
> Arlidge cited by Posner (1973)

At the turn of the 20th century new regulations required those in specific occupations to be examined by 'certifying surgeons', namely workers involved in making lead paints, lucifer matches, explosives (with dinitrobenzene), vulcanising rubber (with carbon disulphide) and enamelling iron plates. Notification requirements were introduced for disease caused by lead, phosphorus, arsenic and anthrax. At this time there was a high general prevalence of acute lead poisoning and also 'phossy jaw' in matchmakers

During the First World War, concern heightened about the effects of work on health and efficiency of workers. The hazards of TNT and the organic solvents used in aircraft manufacture were studied. There was a rapid growth in first

aid and industrial medical and nursing services. However, these were short-lived phenomena and numbers declined soon after the war.

1.5 DEVELOPMENT OF OCCUPATIONAL HEALTH LEGISLATION

The emergence of health and safety legislation in a piecemeal fashion has been well documented and much analysed. Robens (1972) cites the preface to *A History of Factory Legislation* (Webb, 1910) which commented:

> "This century of experiment in factory legislation affords a typical example of English practical empiricism. We began with no abstract theory of social justice or the rights of man. We seem always to have been incapable even of taking a general view of the subject we were legislating upon. Each successive statute aimed at remedying a single ascertained evil. It was in vain that objectors urged that other evils, no more defensible, existed in other trades or amongst other classes, or with persons of ages other than those to which the particular Bill applied. Neither logic nor consistency, neither the over-nice consideration of even-handed justice nor the quixotic appeal of a general humanitarianism, was permitted to stand in the way of a practical remedy for a proved wrong."

Detailed law needs to be constantly extended and elaborated to deal with new problems arising from the rapid pace of current industrial development. Robens (1972) identified this traditional approach as unsatisfactory because it was cumbersome and inflexible and could not respond rapidly enough to such change. Robens categorised existing health and safety legislation into three major groups, firstly, that covering large sectors of the working population (for example, those in factories, offices, shops, railway premises, mines and quarries), secondly, legislation requiring special control over certain industrial activities and substances, and finally, legislation covering emissions and effluents from workplaces. This unwieldy body of highly prescriptive law was broadly composed of nine main statutes and 500 statutory instruments.

Oldershaw (1988) focuses specifically on occupational health legislation illustrating the reactive nature of its development:

> "For well over a hundred years in the UK, legislation has been passed with the aim of combating an established ill-health condition clearly resulting from a particular work activity. Disease has been found and steps have been taken to stop the process, prevent exposure, ban the substance thought to be responsible, substitute the substance or, finally, to physically control exposure to the material perhaps by engineering or personal protective means."

This may have been a slow or laborious process but one which had the merit of allowing the explicit demonstration of the effectiveness of applied controls in preventing a clearly recognised health effect. However, there are serious drawbacks where the ill-health is serious, chronic or irreversible. Robens (1972) makes a similar point when citing the Chief Inspector of Factories Annual Report for 1970:

> "The proliferation of more subtle hazards, and particularly potential carcinogens, must also be the subject of continuous vigilance. Cancer-producing chemicals share with asbestos and other fibrogenic dusts a latent period before the disease is manifest. Any failure at the present time to bring these risks under control can only therefore be reaped as a bitter harvest, not by us but by the next generation."

For a long period the control of exposure to toxic substances (in factories) relied on the Factories Act (1961). Section 58 required the provision and maintenance of washing facilities, Section 64 prohibited the partaking of food and drink in rooms used for certain dangerous trades and Section 63 was concerned with controlling levels of airborne substances The latter Section was based on Section 47 (1) of the 1937 Factories Act which required:

> "In every factory in which, in connection with any process carried on, there is given off any dust or fume or other impurity of such a character and to such extent as to be likely to be injurious or offensive to the persons employed, or any substantial quantity of dust of any kind, all practicable measures shall be taken to protect the persons employed against inhalation of the dust or fume or other impurity and to prevent its accumulating in any workroom and in particular, where the nature of the process makes it practicable, exhaust appliances shall be provided and maintained, as near as possible to the point of origin of the dust or fume or other impurity, so as to prevent it entering the air of any work room."

The origin of this section was the first 'occupational health' legislation applied to factories in the 1864 Factories Act. This stated that factories should be ventilated:

> "in such a manner as to render harmless, so far as is practicable, any dust gases or other impurities emitted in the process of manufacture which are injurious to health."

There were relatively few prosecutions under this legislation, since there was a lack of air monitoring techniques to quantify such dust and fume and to determine its injurious nature. This was coupled with a lack of expertise to decide what constituted "practicable measures". Before World War Two, there

were very few specific tolerable limits or air quality standards. In addition, there was little guidance on ventilation design principles for factories in the UK. In the USA, the American Conference of Governmental Industrial Hygienist's (ACGIH) first published an *Industrial Ventilation Manual* in 1951.

Special regulations made under the Factories Acts prohibited the use of some substances and controlled the circumstances in which specified materials such as asbestos (The Asbestos Regulations 1969), chromic acid (The Chrome Plating Regulations 1931) and lead (various Regulations) could be used in manufacturing processes. There were other relevant statutory provisions such as the Agriculture (Poisonous Substances) Act 1952 where 40 chemicals were scheduled and had specified prescribed precautions for their use. However, Robens (1972) commented:

> "Many toxic substances in many industrial circumstances are not directly regulated by statutory provision."

As a result, the *Health and Safety at Work etc., Act 1974* placed new general duties on users, manufacturers and suppliers of chemical substances. However, these had limited effectiveness, even after enactment of other regulations dealing with the toxicity of new substances (*Notification of New Substances Regulations 1982* (NONS)) and the classification, packaging and labelling of substances (*Classification Packaging and Labelling Regulations 1984* (CPL)). HSE (1985) stated that over 100,000 substances were registered with the 'European Inventory of Existing Commercial Substances' (EINECS). These would not be treated as 'new substances' for the purposes of the NONS Regulations and for such materials pre-market testing would not be required.

The traditional approach to the use of substances was *de facto* to assume that they were safe until there was overwhelming evidence that this was not the case, at which point action would be taken. Unfortunately such action often concentrated on compensation at the expense of preventive strategies. The HSE published a toxic substances philosophy in 1976 as a guidance note (HSE, 1976). This suggested that *all* substances should be regarded as potentially harmful and that all exposure should be kept as low as reasonably practicable.

There was an increasingly strong feeling that specific regulations concerned with controlling of all toxic substances were required.

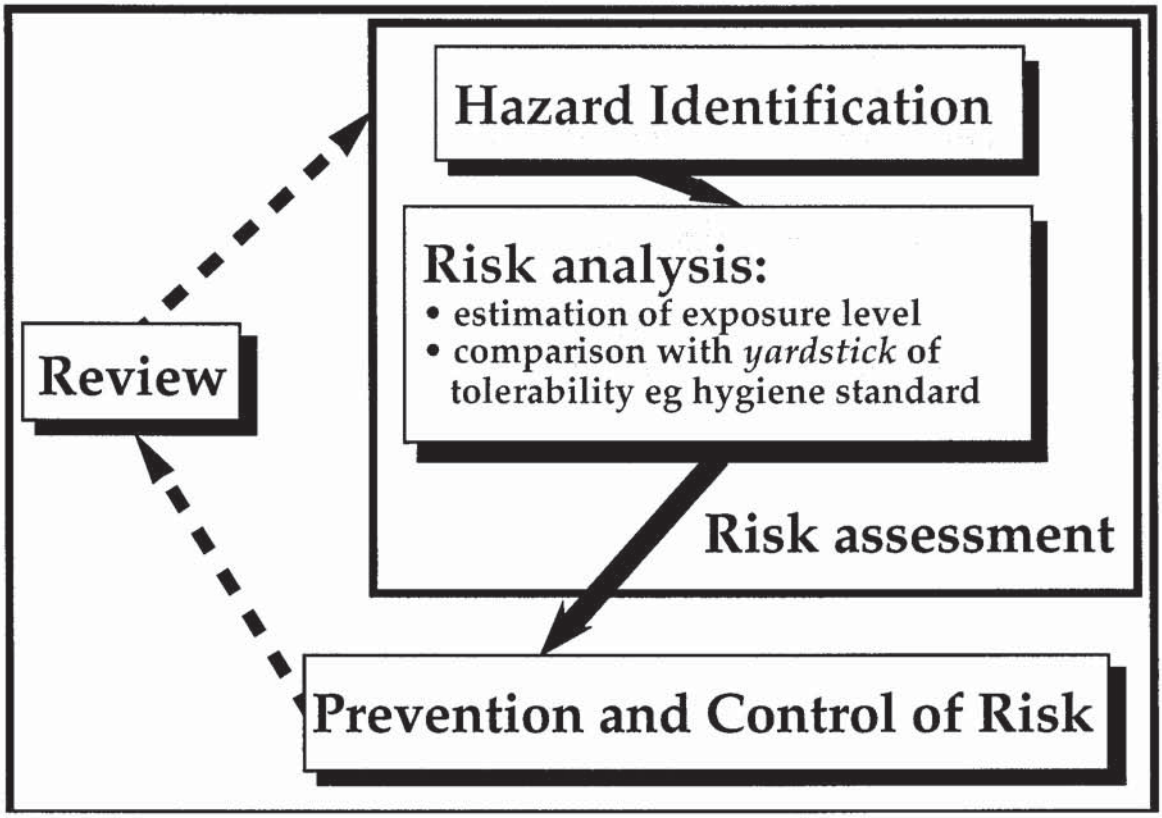
In Great Britain a series of well-documented occupational diseases caused by exposure to substances (for example, asbestos and aromatic amines) resulted in the introduction of various controls including the enactment of specific legal regulations. There have been similar concerns in the rest of Europe and this has provided the impetus for a series of European Union (formerly Community) Directives aimed at preventing or controlling exposure to hazardous substances at work.

In Great Britain, in 1988, the *Control of Substances Hazardous to Health Regulations* (COSHH) were enacted. This legal code required competent risk management of all situations where people were exposed to 'substances hazardous to health' (defined in the Regulations) arising as a result of work activity. These regulations required, for the first time, the systematic identification of all such substances as used by an employer, the assessment of health risks arising, the implementation of prevention or adequate control measures and a regular review of this whole process. The aim was to remove most of the piecemeal regulations relating to toxic substances in order to broaden the coverage of the law and to make the duties of employers and occupiers more intelligible.

1.6 FUTURE PREVENTIVE APPROACH

COSHH requires a *pro-active* risk management approach as opposed to the reactive approach applied to managing hazardous substances in the past. The difficulties, discussed above, in recognising much ill-health as occupationally-induced makes pro-active risk assessment an imperative. Since current exposure to substances at work could cause a significant level of chronic disease at some time in the future, it is necessary to apply competent, systematic risk assessment *now* to prevent or reduce the risk of such ill-health. This general preventive approach is illustrated below (Figure 1.3) and is now the key focus for the efforts of occupational health (and safety) practitioners. The terms used are defined in Chapter Two.

Figure 1.3 Risk management framework



1.6.1 OCCUPATIONAL HYGIENE - THE KEY CENTRE OF EXPERTISE IN HSRA

Although an identifiable risk management approach has been applied for a considerable time in occupational hygiene (since the 1940s by industrial hygienists in the USA) risk assessment-driven legislation was first introduced in the UK with the 1980 *Control of Lead at Work Regulations* followed by the *Control of Asbestos at Work Regulations* in 1987. The COSHH regulations broadened this approach to all 'substances hazardous to health' in 1988. Risks must be assessed for all employees and others who may be exposed as a result of work activity. As discussed above, during the 1980s, other complementary regulations concerned with substances were enacted, first, with respect to adequate testing of new materials came the *Notification of New Substances Regulations 1982* (consolidated in 1993). Second, concerning the classification, packaging and labelling of materials came the *Classification, Packaging and Labelling Regulations 1984* (now replaced with the *Chemicals (Hazard Information and Packaging) Regulations 1994*).

The original COSHH regulations required initial assessments to have been completed by October 1989. HSE concluded in a review that the most important problems with the implementation of the regulations were with 'inadequate assessment'. The HSE carried out a baseline survey in 1989 with a follow-up exercise in 1992 to examine systematically the impact of COSHH. For 'all companies' in the sample, a complete absence of any assessments was found in 12% and assessments which were not deemed 'suitable and sufficient' were found in 27%. In companies 'with less than 50 employees' these figures were proportionally larger, at 23% and 37% respectively. The report (HSE, 1993) commented:

> "The most common fault has been for assessments to consist of little more than collections of hazard data sheets or other information about the hazards on the premises, without the all important evaluation of risks arising from these hazards."

This is still a common fault with many current 'Assessments' made under the COSHH Regulations.

Occupational hygiene embodies the discipline which most closely addresses hazardous substance risk assessment in terms of requisite skills and demands on knowledge. The appropriateness of occupational hygiene skills is recognised by authoritative guidance published to assist industry to comply with the COSHH regulations (HSE, 1988a):

> "An appreciation of occupational hygiene skills is important. The training which occupational hygiene professionals have undergone makes them uniquely suited to much of the work of assessment."

However, this does not mean that it is necessary to have an 'occupational hygienist' in order to carry out such assessments. A further comment (HSE, 1988a) highlights the importance of sound knowledge and experience of work processes likely to be possessed by local managers, which can be supplemented by suitable training:

> "In the most straightforward cases, sound assessments can be made by one or several people having a thorough knowledge and experience of the work and processes, but many assessments will require some additional training in the principles of occupational hygiene, which are relevant to the workplace being considered."

However, following the implementation of the Regulations, it became increasingly obvious from the quality of the early assessments that such training was not being provided. The report of an HSE-commissioned study was published in 1992, in which the objective was to assess the supply of, and demand for, education and training in occupational hygiene with particular reference to toxic substances (Toye *et al.*, 1992). This study concluded that:

> "Just over half of employers have not made use of training relevant to the COSHH, lead or asbestos regulations, or provided it themselves. Most of these are small businesses with fewer than 50 employees."

It is not surprising that the report further concluded:

> "There is a shortage of people with qualifications in occupational hygiene."
>
> "Learning to make assessments is very difficult for many of those who are expected to do the task, partly because of lack of scientific background and relevant health and safety experience."
>
> "Education and training have a major part to play in helping employers and employees understand the requirements of the regulations and put them into effect."

The conclusion that may be drawn from the foregoing is that the character of legislation is now much more appropriate to the promotion of pro-active controls than hitherto. However, decisive limitations on effective implementation of this legislation are the limited number of occupational hygienists and the lack of adequate training for others charged with carrying out this task.

1.7 RESEARCH PLAN AND THESIS STRUCTURE

The impetus for the research originated from the recognition that there is a shortage of people competent to carry out hazardous substance risk assessment. The basic aim of the research is to explore the nature of the expertise necessary to carry out competent hazardous substance risk assessment *inter-alia* in order to help non-specialists carry out this task. The research plan and structure of this thesis will now be described.

1.7.1 RESEARCH PLAN

The research aims to:

1. investigate the nature of, and make explicit, the expertise of occupational hygienists in HSRA;
2. investigate the approach of other health and safety professionals in HSRA;
3. develop an integrated view of contemporary best practice in HSRA and to identify training needs.

More specifically the objectives are to:

1. review the context of hazardous substance risk assessment and to define its scope;
2. locate hazardous substance risk assessment expertise and examine its origins and development;
3. review current knowledge on the general aspects of 'expertise' in order to develop a methodology for eliciting the expertise of HSRA;
4. develop and apply a practical risk assessment 'aid' to help a non-expert carry out this task;
5. study, using various methods, the approach to hazardous substance risk assessment used by occupational hygienists and others;
6. carry out a practical study to compare and contrast the approach of other specialist groups (operating in the field of occupational health and safety) in order to highlight specific training needs.

1.7.2 THESIS STRUCTURE

An outline of the content of the chapters in this thesis together with a route map (Thesis route map

A pathway is described in the diagram below to guide the reader through this work.

Figure 1.4) is given below:

CHAPTER ONE has introduced aspects of current occupational health problems with toxic substances and examines the difficulties in obtaining good quality quantitative ill-health data. It sought to develop an historical perspective on the control of occupational exposure to hazardous substances leading up to the modern risk management approach.

CHAPTER TWO reviews the development of the approach to HSRA entailing reference to development of industrial hygiene in the USA and occupational hygiene in the UK. The objective is to demonstrate that occupational hygiene is the key centre of expertise for this activity.

CHAPTER THREE outlines the nature of 'expertise' in general terms and the methods which have been used for eliciting knowledge from expert practitioners in different fields of endeavour. This is to serve as a guide for this work in developing a method to study expertise in HSRA.

CHAPTER FOUR outlines the development of the methodology used in this research.

CHAPTER FIVE reports exploratory interviews and risk assessment visit with experienced occupational hygiene practitioners.

CHAPTER SIX describes a pilot study in which a videotape was used to portray a real industrial scenario. This was used in a practical exercise to elicit expertise from occupational hygiene practitioners and trainee health and safety inspectors. This preliminary study revealed a need to analyse verbal transcript data using a structured model of the HSRA activity.

CHAPTER SEVEN outlines a model (HSRA Model A) developed *inter-alia* following extended focused discussions, using familiar case-studies, with an experienced occupational hygienist.

CHAPTER EIGHT reviews the development of an aid to assist industrial managers with HSRA and information obtained from the associated training.

CHAPTER NINE outlines the derivation of a generalised model for hazardous substance risk assessment (HSRA Model B) based on information from the above sources. This model is used to structure the analysis of data collected in the experimental study described in Chapters Ten, Eleven and Twelve.

CHAPTER TEN follows and extends the pilot study (Chapter Six, above) and describes an experimental study to investigate the approach used in HSRA by occupational hygienists and other health and safety specialists. The other specialists were occupational health nurses, occupational health physicians, health and safety practitioners and trainee health and safety inspectors.

CHAPTER ELEVEN reports the findings from the study described in Chapter Ten. The results are interpreted with the model described in Chapter Nine, with subsequent discussion and conclusions.

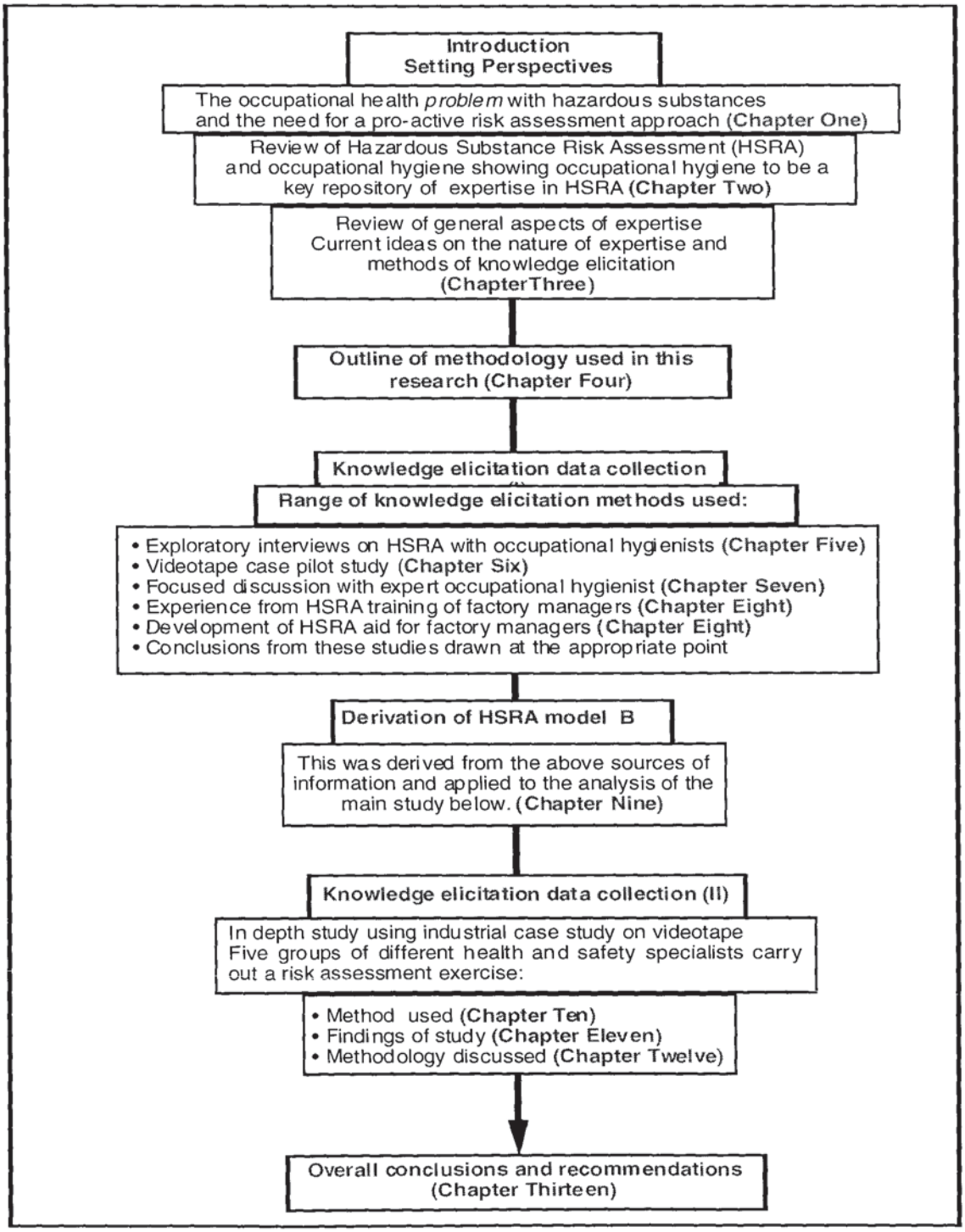
CHAPTER TWELVE reviews critically the methodology used in the experimental study and how the method could be improved.

CHAPTER THIRTEEN presents the findings of the research with overview conclusions and recommendations for further work.

1.6.3 THESIS ROUTE MAP

A pathway is described in the diagram below to guide the reader through this work.

Figure 1.4 Thesis route map



2.

Hazardous substance risk assessment and occupational hygiene

"[...] the doctor no longer knows everything about everything."

E. R. Merewether, Chief Medical Inspector of Factories (UK)
addressing the American Public Health Association in 1942

2.1 INTRODUCTION

Chapter 1 dealt mainly with demonstrating current occupational health challenges and developing historical and regulatory perspectives. Further, a demand was shown for expertise in hazardous substance risk assessment and it was asserted that occupational hygiene skills were appropriate for much of this task. This chapter reviews key aspects of hazardous substance risk assessment and discusses the activities of occupational hygiene and hygienists. The development of the occupational hygiene discipline is followed in the USA and the UK in order to demonstrate that many of its activities and interests have been directed towards improving knowledge and capability in HSRA.

2.2 PRINCIPLES OF SUCCESSFUL HEALTH AND SAFETY MANAGEMENT

The Health and Safety Executive (HSE, 1991) has produced an influential guide dealing with the issues and principles involved for organisations seeking to achieve successful health and safety management. This guide was intended to assist organisations effect an improvement in their health and safety performance.

The following key elements were linked with achievement of successful health and safety management:

- POLICY
- ORGANISING
- PLANNING AND IMPLEMENTING
- MEASURING PERFORMANCE
- REVIEWING PERFORMANCE

- AUDITING

Each of these elements are briefly outlined below:

POLICY

Organisations which are successful at managing health and safety have effective and well developed health and safety policies.

ORGANISING

Successful organisations are structured such that they can put health and safety policy into effective practice.

PLANNING AND IMPLEMENTING

They have a planned and systematic approach to policy implementation and use risk assessment methods to decide priorities and set objectives for hazard elimination and risk reduction. Performance standards are established and performance is measured against them, a practice discussed further below.

MEASURING PERFORMANCE

Performance is measured against pre-determined standards. This reveals where and when action is needed to improve performance. There should be pro-active self monitoring to determine the success of action taken to control

risks and intensive reactive monitoring where a failure has been identified (for example, the occurrence of a case of occupational disease).

AUDITING AND REVIEWING PERFORMANCE

This involves learning from all relevant experience and applying lessons learned in a feedback loop. Auditing involves an independent assessment of the validity and reliability of planning and control systems.

More recently, building upon this approach, the British Standard Guide 8800 (BSI, 1996) has been published which aims, with detailed practical advice, to assist organisations to develop effective health and safety management systems.

2.2.1 PERFORMANCE STANDARDS FOR THE CONTROL OF HAZARDS AND RISKS

The guide to successful health and safety management (HSE, 1991) highlights performance standards as vital for effective control of risks. The setting of standards is seen to involve four key stages:

HAZARD IDENTIFICATION

RISK EVALUATION

RISK CONTROL

IMPLEMENTING AND MAINTAINING CONTROL MEASURES

These steps represent fundamental principles in health and safety risk management and have been incorporated into risk assessment-driven legislation such as the COSHH, Noise at Work and the Management of Health and Safety at Work Regulations. HSE (1991) acknowledges that a distinctive approach may be needed in the case of health risks, because of the inherent features of such risks and that in many cases it is difficult to make the connection between occupational cause and the harmful ill-health outcome. It concludes that because of the complexity of health risks, specialist expertise may needed for this type of risk assessment, which may require measurement

of exposure to a hazard involving complex technical equipment and trained personnel. Assessing the effectiveness of control measures in this context may also involve technical measurements of the work environment.

2.2.2 DEFINITION OF TERMS

The terms 'hazard', 'risk' and 'risk assessment' are used in many publications and with different contexts and need to be defined for the purpose of this research. The definitions (below) are taken from the British Standard Guide 8800 (BSI, 1996).

Hazard

A source of potential harm or damage or a situation with potential for harm or damage.

Risk

This is the combination of the likelihood and the consequences of a specified hazardous event (accident or incident). A risk then always has two elements:

1) the likelihood that a hazard may occur

2) the consequences of the hazardous event

Risk assessment

This involves three basic steps:

a) identify hazards

b) estimate the risk from each hazard – the likelihood and severity of harm;

c) decide if the risk is tolerable.

2.3 APPROACHES TO RISK ASSESSMENT

Risk assessment is a process where judgements are made about the harm that might arise from work activities and processes and the likelihood, that harm will occur. The key objective is to determine whether existing or planned

preventive or control measures are adequate. Booth (1995) identifies four categories of risk assessment relating to:

- major hazard industries;
- substances and energies hazardous to health;
- the design of plant and machinery;
- general workplace hazards.

2.3.1 RISK ASSESSMENT AND MAJOR HAZARD INDUSTRIES

Risk assessment is needed to assure organisations, regulatory authorities and the general public that the risks from major hazard installations such as nuclear or large chemical plants are under adequate control. A range of techniques for major hazard risk assessment have been developed including:

For hazard identification

Hazard and Operability Studies (HAZOP) (This technique is not exlusively used in major hazard situations); Failure Mode and Effects Analysis (FMEA);

For risk estimation

Fault Tree Analysis (FTA); Event Tree Analysis (ETA) Hierarchical Task Analysis (HTA) and Human Reliability Assessment (HRA)

For developing risk tolerability criteria

Cost Benefit Analysis (CBA); and Cost-Effectiveness Analysis (CEA)

2.3.2 RISK ASSESSMENT AND SUBSTANCES AND ENERGIES HAZARDOUS TO HEALTH

Risk assessment techniques are well developed for many health hazards. Whether the hazard is a substance, noise or radiation, the assessor attempts to estimate an exposure 'dose' for the person(s) at risk. This parameter is then compared with derived risk tolerability criteria.

2.3.3 RISK ASSESSMENT AND THE DESIGN OF PLANT AND MACHINERY

This category of risk assessment is primarily concerned with safety risks although health risks would be considered where appropriate (for example, noise). It would cover predicted continuing and contingent hazards. The key task is to eliminate hazards by design and if this is not possible, to adequately reduce risks. There is scope for use of the quantified risk assessment techniques (from major hazard risk assessment) but usually in this area semi-quantitative techniques are applied.

2.3.4 RISK ASSESSMENT AND GENERAL WORKPLACE HAZARDS

This category covers other hazards not specifically not dealt with by the above classes of risk assessment. The approach is to identify hazards and assess risks arising, using a qualitative approach. A primary objective is to rank relative risks in terms of priority for action.

There are overlaps between these four categories of risk assessment. There is scope for the quantitative methods developed for major hazard industries to be applied qualitatively to general workplace hazards and to hazards from substances and energies. In this research it is specifically hazardous substance risk assessment that is of primary interest, and provides the focus for the discussion below.

2.4 ELEMENTS OF RISK ASSESSMENT

Each of the categories of risk assessment, mentioned above, embraces the following general elements:

- define system, process or work activity;
- gather all relevant information;
- identify hazards;
- analyse risks;
- determine tolerability of risks.

These two final elements complete the whole risk management cycle:

- determine further control measures;
- audit and review the whole process.

These aspects will be discussed below focusing on risks arising from exposure to substances hazardous to health.

2.4.1 RISK ASSESSMENT STAGES

2.4.1.1 Define system, process or work activity

This requires the assessor to determine the limits of the risk assessment.

2.4.1.2 Gather all relevant information

This stage involves *inter alia* determination of the process specification, the operating conditions, the nature of the tasks that people carry out, the substances used, temperatures and pressures involved. This enables an assessor to build a full picture of the process and to determine what further information is needed to carry out a risk assessment. With substances hazardous to health this involves the collection of relevant material data safety sheets and other chemical safety and toxicity data.

2.4.1.3 Hazard identification

The next step is to identify hazards. This may result from an inspection of a work process or may be suggested by the signs and symptoms of disease in exposed people or identifying situations where people may have harmful exposure to substances, relating to inhalation, ingestion and skin absorption/contact. This would take into account supplied hazard data as well as worker complaints of irritation or discomfort, sickness absence rates and inexplicably high staff turnover.

2.4.1.4 Analysis of risks

Having identified exposure hazards, the assessor examines the working process to decide which are likely to be significant intolerable health risks. It is

necessary to estimate or quantify the extent of exposure to the hazard, which may be used to determine the level of risk to workers' health. In some cases this may only require subjective or semi-quantitative assessment, whilst on other occasions, practical measurements using technical equipment, will be needed, for quantitative assessment of airborne contaminants. Health risk estimation methods normally seek to determine a person's exposure to a hazard in terms of estimated 'dose'[1]. In this context, exposure dose is a surrogate estimate of risk.

A common method of estimating inhalation dose, is to monitor airborne contaminants in a worker's breathing zone over a defined period of time. There are many well-validated specific techniques for collecting and analysing airborne contaminants in order to estimate inhalation dose (HSE, *Methods for the Determination of Hazardous Substances* Series). Such estimates may then be compared with derived air quality standards in order to determine risk tolerability. Air monitoring may be carried out for a variety of reasons, but for this discussion we are interested, primarily, in measuring long-term or short-term worker exposure to hazardous substances. This should usually be carried out by 'personal monitoring', where measurements are made in the breathing zone (usually lapel) of exposed people.

It is possible to estimate exposures taking account of other routes of absorption such as skin absorption and ingestion, by techniques collectively known as 'Biological monitoring'. Toxic substances or suitable indicators of uptake are measured in various body fluids. However, validated biological monitoring methods (and standards) are only available for a relatively small number of substances in comparison to number of approved air contaminant monitoring methods. Overall, air contaminant monitoring and biological monitoring can be seen to provide complementary information on health risk exposure. Each category of monitoring has its advantages and disadvantages (Tola and

[1] Dose is the total quantity of a substance or energy which the body absorbs over a specified period of time.

Hernberg, 1981). However, this thesis is not the place for a detailed discussion of this topic.

2.4.1.5 Determine tolerability of risks

Once personal exposure to the hazard in a situation has been estimated or measured, (this representing an estimate of risk) then this is compared with a derived tolerability standard, which may be an air quality standard or biological index value. The assessor makes the comparison to decide whether or not the current level of risk is tolerable.

It is difficult to set tolerability standards for health risks and this is discussed briefly below.

Nature of harm and toxic effects from substances hazardous to health

Most substances when coming into contact or gaining access to the body will cause some change to normal function, which may be harmful. The nature of the interaction between substances and people is problematic in that substances may cause harm in different ways and a range of factors will influence the nature and severity of that harm. For instance, skin contact with relatively small quantities of a strong mineral acid (for example, sulphuric acid) will cause burns and destruction of tissue. This reaction is likely to be similar in different individuals. However, a known human carcinogen such as benzene (which is toxic at low concentrations and with a latency period) does not cause cancer in every person significantly exposed. Furthermore, substances which cause harm in vulnerable body target organs such as the nervous system or kidney, do not have the same effects on everyone (even with similar exposures). Gompertz (1981) cites the example of a medical study, which dramatically illustrates this biological variation. There is inherent biological variation between individuals relating to, for example, body size, weight, dietary status, sex, age. There is a parallel variation between individuals at the biochemical level. These factors influence the way in which the body handles toxic materials and by which these may exert their effects. Because of this, it is difficult to specify clear universal indicators (or tolerable standards) in order to prevent harm in a group of heterogeneous individuals.

Ideally, for a defined population, a dose response relationship should be used to set a standard, which shows this biological variation in response to the harm. However, this information is not usually available when standards are being set.

An extreme case of this variation in general responsiveness to toxic materials manifests itself in damaging 'sensitisation' reactions where some individuals respond excessively and inappropriately, immunologically, at very low levels of exposure to a substance. (Sensitisation results from changes to the immune system which normally protects the body from the harmful effects of chemical contaminants which either come into direct contact with the skin or which are airborne and enter the body via inhalation.) It is likely that everyone is hypersensitive to some substances and as we go through life, the hope is that we do not come into contact with our potential sensitisers, particularly at work.

Futhermore, depending on exposure pattern, the primary target organ for a substance may change. A high exposure over a short period may produce acute health effects in one target organ, whilst lower long-term exposure may primarily harm another target organ. For example, alcohol intoxication will have acute effects on the nervous system and with long-term exposure, damage may occur in the liver. Tolerability standards are set to protect against both short- and long-term health effects.

2.4.1.5.1 Air quality standards

For substance inhalation hazards tolerable risk is often defined in terms of quantitative air quality standards. These standards represent indicators of potential inhalation dose, and are often expressed as an averaged airborne concentration of contaminant measured over a defined period of time (usually either 8 hours or 15 minutes). The standards assume measurements are taken in the exposed person's 'breathing zone', which by convention is generally taken to be the lapel. Measured (or subjectively)estimated personal airborne contaminant exposures are compared with these standards. In the UK, the HSE's "Occupational Exposure Limits" (OELs) (see below), are used for compliance purposes. In many other countries the 'Threshold Limit Value'

system of standards of the American Conference of Governmental Industrial Hygienists (ACGIH) is used. Roach (1992) estimates that about one thousand individual tolerability standards have been derived for air contaminant exposure. Unfortunately, for many substances used in the workplace there are no published standards by which to interpret exposure. This poses a major problem for organisations using such substances, particularly small and medium-sized enterprises, who do not have the resources or expertise to derive their own in-house limits. (It poses a big enough problem to the largest companies!)

The criteria by which these standards have been derived vary widely with the nature of the harm they seek to prevent. The Threshold Limit Value (TLV) system is that developed and published in the USA by the ACGIH which in spite if its title is a non-governmental organisation. It is a scientific society similar to the British Occupational Hygiene Society. The preface to 1996 ACGIH TLV List states:

> "Threshold Limit Values refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects."

The preface goes on to state that because of individual variation in susceptibility some workers will suffer effects ranging from discomfort to sensitisation to chemicals and occupational disease at exposure levels well below the TLV. The basis for TLVs is intended to be reasonable freedom from irritation, narcosis, nuisance or impairment of health for the majority of workers. Reference to TLVs relates to these US based standards, which have been adopted for use in many countries.

"Adequate control" of exposure and tolerable risk standards in the UK

In the UK various yardsticks or standards are cited either implicitly or explicitly in legal requirements. At a general level, Section 2(1) of the Health and Safety at Work etc. Act 1974 requires an employer:

> ".... to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees."

With exposure to "substances hazardous to health" COSHH (Regulation 7) requires prevention or adequate control of all routes of exposure. For inhalation exposure, specific reference is made to two classes of compliance standards:

> "7(4) .... where there is exposure to a substance for which a maximum exposure limit is specified in Schedule 1, the control of exposure shall, so far as the inhalation of that substance is concerned, only be treated as being adequate if the level of exposure is reduced so far as is reasonably practicable and in any case below the maximum exposure limit."

> "7(5) .... where there is exposure to a substance for which an occupational exposure standard has been approved, the control of exposure shall, so far as the inhalation of that substance concerned, be treated as being adequate if - (a) that occupational exposure standard is not exceeded, or (b) where the occupational exposure standard is exceeded, the employer identifies the reasons .... and takes action to remedy the situation as soon as reasonably practicable."

Compliance is based on two types of air quality standard ie, the "Maximum Exposure Limit" (MEL) and the "Occupational Exposure Standard" (OES). The MEL is the maximum concentration of an airborne substance, averaged over a reference time period (eight hours or 15 minutes), to which employees may be exposed by inhalation under any circumstances. The OES is the concentration of an airborne substance, averaged over a reference period, at which:

> ".... according to current knowledge, it is believed that, there is no evidence that it is likely to be injurious to employees if they are exposed by inhalation, day after day at that concentration."

An updated list of these standards is produced annually (HSE, 1997). The HSE has developed "Indicative Criteria" as guidelines for adopting a particular class of limit for a specific substance. To be assigned an OES a substance must meet each of the following criteria:

> "(1) reasonable certainty that substance is not injurious at the identified concentration with exposure day after day; (2) exposure to higher concentrations which may be expected in practice are unlikely to cause serious short or long-term effects; (3) available evidence indicates that compliance with the OES is reasonably practicable."

To be assigned an MEL a substance must meet either of the following criteria:

> "(4) available evidence does not satisfy 1 and/or 2 above and exposure may have serious health implications; (5) socio-economic factors indicate that although a substance meets 1 and 2 above a numerically higher value is needed if controls for certain uses are to be regarded as reasonably practicable."

The COSHH regulations also require adequate control of exposure by routes other than inhalation including skin contact, skin absorption and ingestion. Evaluation of health risks arising from exposure by skin contact/absorption and ingestion routes is often carried out qualitatively by careful examination of activities.

2.4.1.5.2 Biological monitoring

As has been noted above, 'biological monitoring' can be carried out, where appropriate, to estimate overall body uptake of substances by all routes. Biological monitoring has been defined as:

> "Biological monitoring can be defined as a regular measuring activity where selected, validated indicators of the uptake of toxic substances are determined to prevent health impairment."
>
> (Tola and Hernberg, 1981)

For interpreting biological monitoring measurements in terms of tolerable health risk, "Biological exposure indices" and "Biological limit values" have been derived by the HSE and the ACGIH respectively. There are many fewer available biological limits in comparison to air quality standards. Currently, for HSE's Biological Monitoring Guidance Values (BMGVs), limits for only six substances are listed (HSE, 1997).

2.4.1.6 Determine further control measures

Once a conclusion has been formed on whether or not a defined risk is tolerable, then a decision needs to be taken regarding current or any planned control measures. A wide range of strategies are available to achieve adequate control, which will depend, in each case, on the particular circumstances. There are a range of possible options: a complete re-design of the process;

elimination of the hazard; installing a local extract ventilation system, requiring the workers to wear personal protective equipment.

Principal control options are listed below:

- elimination of a hazard by process modification;
- initial design of a process without a specific hazard;
- substitution of a substance for an alternative known to be less hazardous;
- segregation of a hazard making it physically remote from workers;
- local extract ventilation;
- dilution ventilation;
- personal hygiene and good housekeeping;
- reduced time exposure of workers to a hazard;
- personal protective equipment to be worn during exposure.

The above list is often referred to as the 'general hierarchy of control' with the measures conventionally presented in order of preference. However, in a specific situation it is common to use an optimum 'blend' of available options. Regulatory provisions, such as COSHH or *The Noise at Work Regulations 1989*, preferentially require measures such as hazard elimination and engineering control where this is thought to be "reasonably practicable".

2.4.1.7 Audit and Review

At appropriate regular intervals there should be an audit and review of the whole risk assessment and control strategy to ensure that controls remain adequate.

This risk management cycle has been the explicit strategic approach of occupational hygiene in the management of toxic substances and other health hazards for a considerable period of time. This approach was explicitly

widened to other hazards in the *Management of Health and Safety at Work Regulations 1992* and in the authoritative guidance described above. It is evident that this framework has now been made the key focus for the achievement of successful health and safety management.

2.5 MODELS FOR HSRA

The following basic framework for risk assessment was discussed above:

- define system process or work activity;
- gather all relevant information;
- identify hazards;
- analyse risks (estimate risks and determine tolerability of risk).

The cycle is completed with the final stage to implement and maintain control measures. Issues specific to generic HSRA were discussed in Chapter Two, for example, information required for the identification of toxic substance hazards, the derivation of tolerability standards and the measurement of personal exposure to substance hazards.

2.5.1 SELECTED EXAMPLES

In the occupational hygiene literature several models have been proposed. Sherwood and Alesbury (1986) propose a comprehensive diagram ('quasi-algorithm') to capture elements of the '*Systematic approach and strategy of occupational hygiene.*' The model is divided into five stages:

- Stage 1: preparation;
- Stage 2: appraisal;
- Stage 3: programme resolution;
- Stage 4: sampling and assessment;
- Stage 5: control.

The result is a number of helpful, if complicated and in some cases difficult to follow, flow-diagrams.

Stage 1 Preparation is included as an example below (Figure 10.1). The authors' stated intention is to restrict the model to airborne substances which may be become a toxic hazard. However, they assert that the principles may be applied to any chemical, physical or biological hazard encountered in the workplace. Use of the model assumes possession of considerable knowledge by the user, for example, 'Does this suggest a problem?', 'Is existing information adequate?' are questions posed by the model at an early stage. More guidance than this would be needed for the non-expert in occupational hygiene. For example, with results from environmental measurements it suggests 'Apply criteria' (Stage 4), which again will only mean something to the relatively expert.

Sherwood and Alesbury (1986) emphasise two points, first, the need to obtain measurements that represent the exposure of individual workers to the hazard, and second, the need to provide economically and socially acceptable control measures complemented by adequate training in their use and maintenance. The authors comment that the model is not intended to be absolute but to serve as 'aide-memoire' to:

> "... guide those concerned with improvement of working conditions."

The Sherwood and Alesbury model represents a helpful and informative overview of the OH strategy for the relative expert, but bringing in physical and biological hazards makes this model more complicated and the logic for these hazards is difficult to sustain in places. The full model is given in Appendix 2.

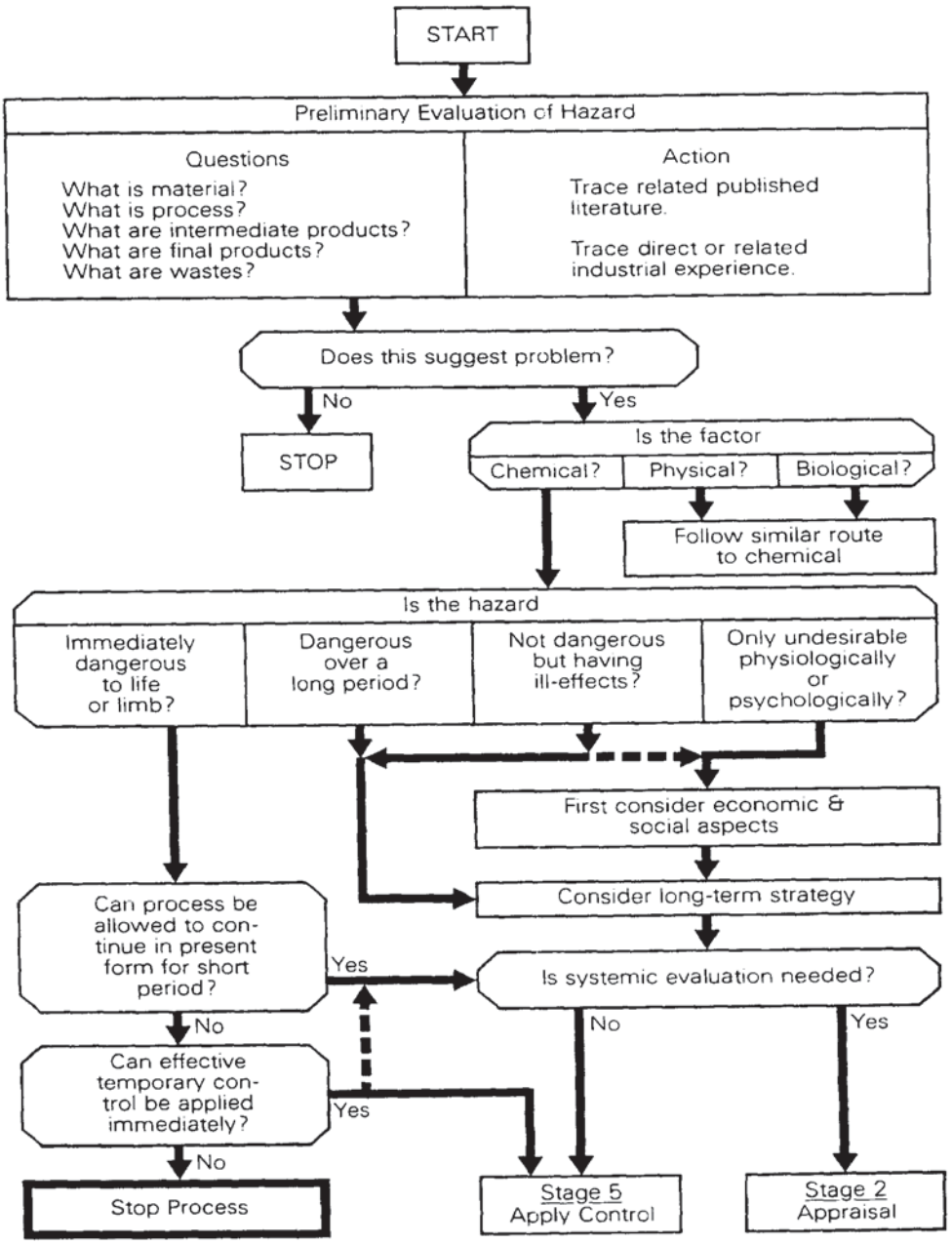
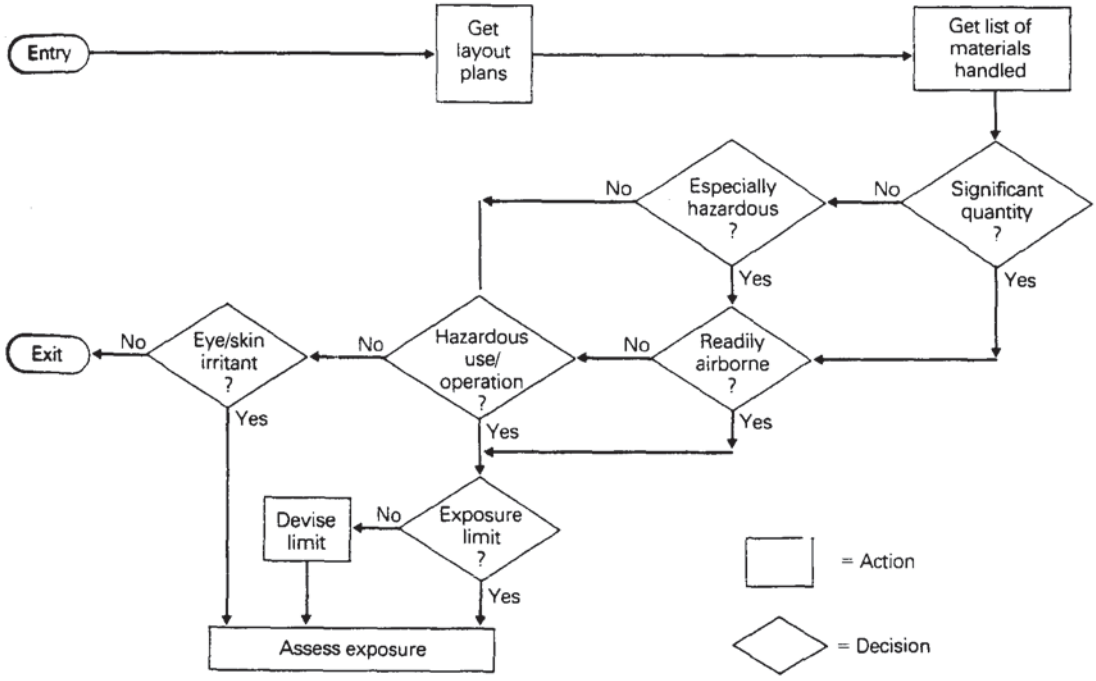


Figure 2-1 OH Model *Stage 1 Preparation* (Sherwood and Alesbury, 1986)

Roach (1992) proposes two relatively simple systems flow-diagrams composed of designated actions and decision-points, which model elements of HSRA. The diagrams represent *'Gathering data to assess health risk'* and *'Assessing exposure'*. He proposes these schemes but acknowledges that the detailed method will vary according to the size, complexity, products and organisation of the company. The diagrams are based upon his personal experience as company hygienist for ICI plc. The action box 'devise (tolerable) limit' (Figure

2-2) would present problems to all but the largest of companies. Some boxes are very general, for example, 'Do workplace inspection' and 'Examine ventilation', although some further information is given in the accompanying text.

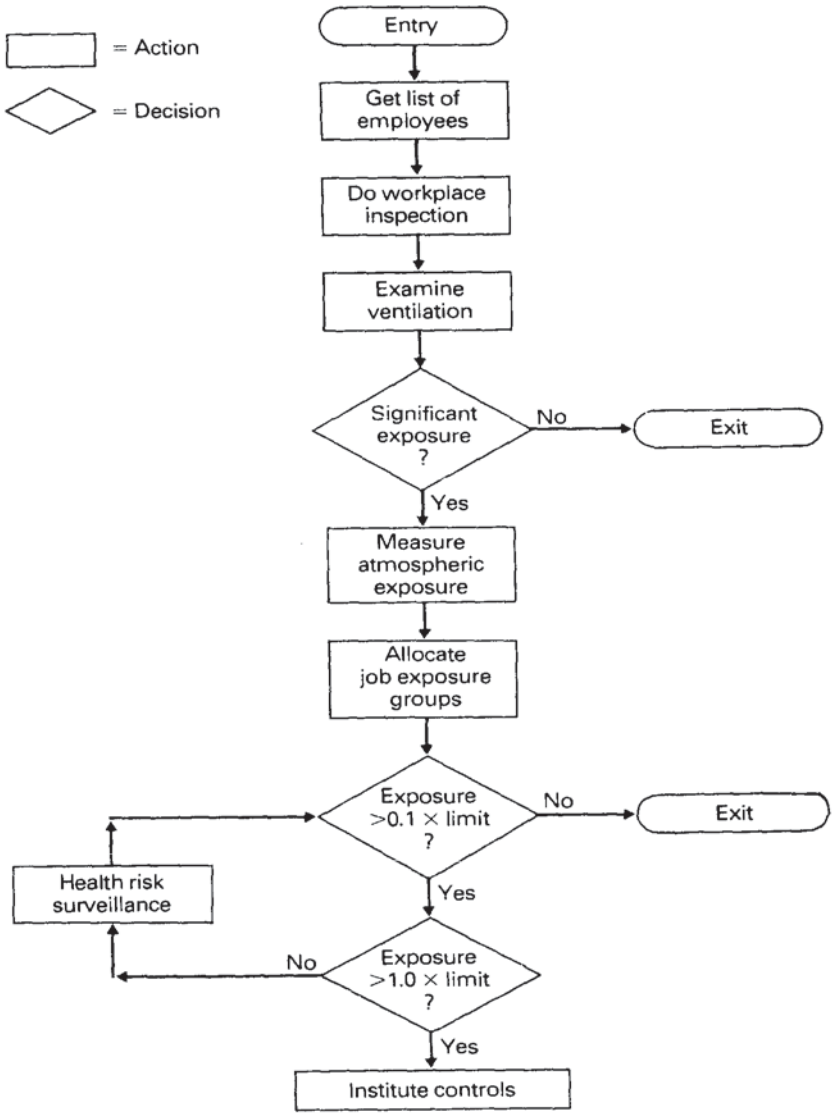
Figure 2-2 ***Gathering data to assess health risk*** **(Roach, 1992)**



Finally, he appears to put much faith in 'limits' in that no controls need to be instituted unless exposures greater than the limit are found. "Adequate control" under COSHH requires that control measures be instituted to reduce exposures "as low as reasonably practicable" where substances have been assigned an MEL. With exposures below the limit Roach requires only 'health risk surveillance".

The hygienists interviewed in (see Chapter Five) in general required levels at around 50% of the limit before controls were instituted, although such a criterion also does not strictly comply with COSHH Regulation 7 in the case of an MEL. The model proposed by Roach does provide, by virtue of its clarity, an accessible pathway for the relatively expert assessor, as was the case with Sherwood and Alesbury (*ibid.*).

Figure 2-3 HSRA Model *Assessing exposure* (Roach, 1992)



Tait (1992) describes an expert system for workplace exposure assessment (WORKSPERT). This system evaluates various hazardous substances, workplace conditions and worker exposures for designated 'homogeneous exposure groups' (HEGs). Substance, workplace and exposure factors are described by 27 attribute variables. The WORKSPERT system allows an air monitoring programme to be determined for each HEG. The air monitoring programme contains recommendations for an appropriate sampling strategy, sampling duration and number of samples to be obtained in the future. It is claimed to be a valuable tool when used by:

> "knowledgeable, qualified technical professionals (for example, safety and health specialists, chemists, engineers, toxicologists, who understand the specific substance, workplace and exposure factors for designated HEGs."

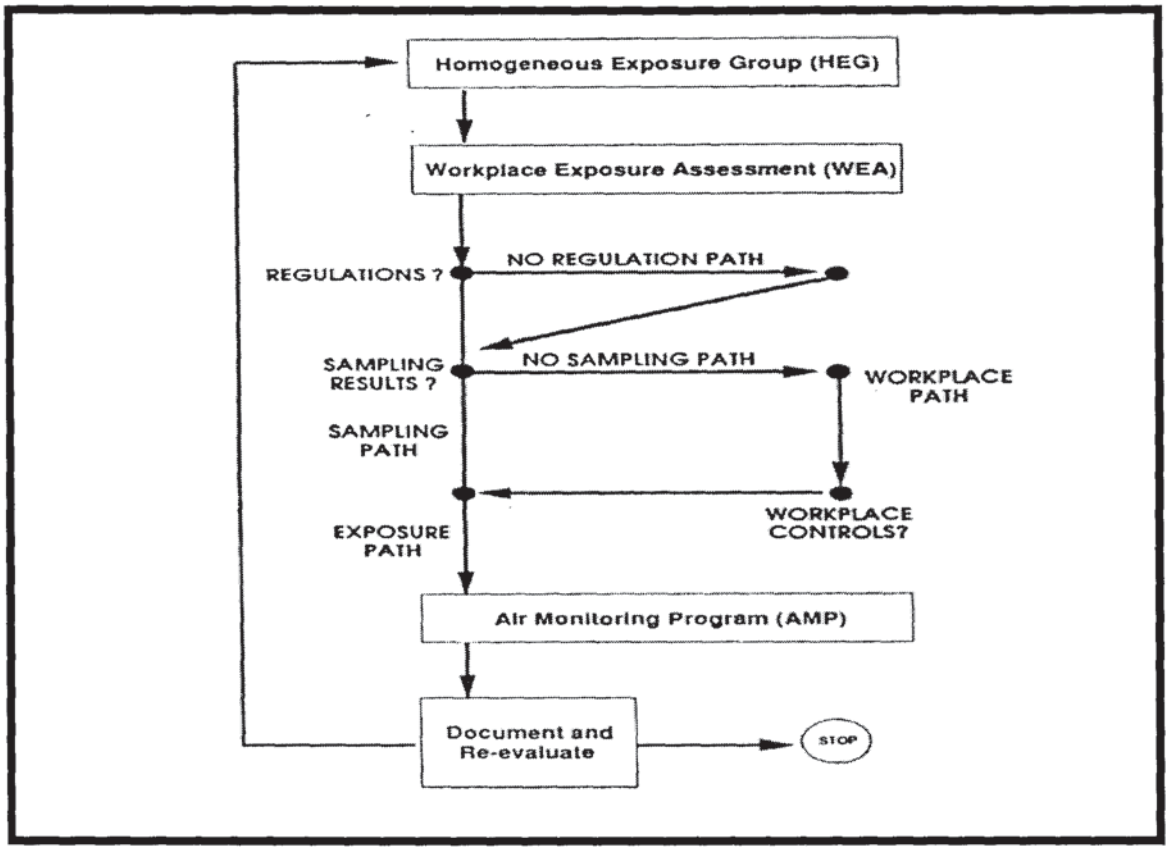
The WORKSPERT system attempts to model the professional judgement of an industrial hygienists and is designed to perform three major functions:

1. Define a homogenous exposure group (HEG).
2. Perform a workplace exposure assessment to qualitatively determine relative risk of work exposure to hazardous substances.
3. Recommend the implementation of additional worker controls or an air monitoring programme to evaluate worker exposures.

The system is designed to assist 'knowledgeable professionals' and is biased towards determining the details of air monitoring programmes following 'exposure assessment'. The overall logic of the system is summarised in Figure 2-4 below. The immediate obstacle to the further development of such systems (Tait (1992) acknowledges), is:

> "the challenge for safety and health professionals to describe the logic they apply when solving complex problems."

Figure 2-4 Logic diagram for Workplace Exposure Assessment Expert System (WORKSPERT)



2.5.2 HSE GUIDANCE

With the implementation of the COSHH Regulations, HSE has produced many publications to guide employers and others. *A Step by Step Guide to COSHH Assessment* was first published in 1988 with a second edition in 1993. HSE (1993) provided guidance and reviewed the general approach to 'COSHH' assessment.

COSHH Regulation 6 - *Assessment*

This Regulation requires the following:

- an assessment of health risks (arising where people are exposed to "substances hazardous to health " generated as a result of work activity);
- a decision on whether current controls provide "adequate control" as defined in Regulation 7;
- a decision on whether action is needed to comply with Regulation 8-12 (Regulation 8: Maintenance of controls; Regulation 9: Use of control

measures; Regulation 10: Air Monitoring; Regulation 11: Health Surveillance; Regulation 12: Information, Instruction and Training.).

General summary headings used in this guidance (HSE *ibid.*) are:

1. Gather information about the substances, the work and working practices.
2. Identify the substances present or likely to be.
3. Identify who could be exposed and how.
4. Evaluating risks to health.
5. Deciding on control measures to comply with Regulations 7-12.
6. Recording the assessment.
7. When the assessment needs to be reviewed.

In discussing the approach to risk assessment, two options are considered by HSE (*ibid.*). First, the assessor is required to take different work activities and look at all exposures in each work activity or task and second, take different substances and see where exposure occurs across different activities. However, HSE (*ibid.*) concludes:

> "In all but the simples cases it is recommended that an activity-based approach will be more effective and easier to manage than a substance by substance strategy."

In these documents, a series of prompts with helpful information, and practical examples are given to guide the assessor. For example:

> "How can a hazardous substance be recognised?"

The guide then goes on to list various information sources providing access to information on hazardous substances. There are also prompts:

> "Identify how the substances are hazardous."

and:

> "Think whether each substance is in a form in which it could be: inhaled; swallowed ...; absorbed .... through skin."

The current guide has many practical realistic examples to aid understanding of what is required by the assessment task.

2.6 OCCUPATIONAL HYGIENE AND RISK ASSESSMENT

The risk assessment framework (Chapter One) has been applied to occupational health hazards for many years by occupational hygienists and those applying occupational hygiene principles. The following section reviews the origins and development of occupational hygiene in order to illustrate its contribution to expertise in hazardous substance risk assessment.

Occupational hygiene is an area of specialist expertise located within the health and safety knowledge domain. Its subject content extends across traditional academic divisions, and unites to embody a unique integrated approach to managing occupational health risks. The discipline had its origins in the USA (as 'industrial hygiene) and only after the Second World War became established in the UK. The terms 'industrial hygiene' and 'occupational hygiene' are broadly interchangeable, in fact with the decline in numbers of 'blue collar' industrial jobs, the term 'occupational hygiene' is increasingly prevalent in the USA. Various definitions of industrial hygiene have attempted to outline its area of operations and scope. Patty (1948) defines 'industrial hygiene' as:

> "... the science and art of preserving health through the recognition, evaluation and control of environmental causes and sources of illness in industry. It resolves itself into the problem of finding factors or conditions in workplaces that may cause or contribute to the illness or serious discomfort of employees, and of devising methods and means of elimination or controlling such conditions."

The American Industrial Hygiene Association (AIHA) defines industrial hygiene as:

> "That science and art devoted to recognition, evaluation and control of those environmental factors or stresses, arising in or from the workplace, which may cause sickness, impaired health and well-being, or significant discomfort and inefficiency among workers or among the citizens of the community."

In the UK context, Robens (1972) identifies 'occupational hygiene' and 'occupational medicine' as the two primary components of the specialism of 'occupational health'. Here, occupational medicine is regarded as being concerned with the diagnosis and treatment of disease by the medically-

qualified person, whereas occupational hygiene is thought to be the province of the scientist or engineer, who is able to identify and control workplace agents causing ill-health or discomfort. In 1986 the British Occupational Hygiene Society (BOHS) defined occupational hygiene more narrowly as:

> "... the applied science concerned with the identification, measurement, appraisement of risk, and control to acceptable standards, of physical chemical and biological factors arising in or from the workplace which may affect the health or well-being of those at work or in the community."

These definitions are all-encompassing, implying a wide range of expertise in the full-time professional occupational hygienist. Ambitiously, many problems of the wider environment around the workplace have also been held to be within the remit of occupational hygiene. In contrast to the American view, this British definition omits any mention of the term 'art' and holds exclusively to the 'applied science' descriptor. Patty (1948) adds a further dimension:

> "It would be a mistake to attempt to give the impression that industrial hygiene is pure science, or that it is restricted to the art of applying scientific principles; much of it involves a liberal use of common sense."

The UK Institute of Occupational Hygienists (IOH), the body which represents the interests of professional hygienists, outlines the scope of occupational hygiene as:

> ".. the application of scientific technological and managerial principles for the protection of health by the prevention or reduction of risks to health from chemical biological or physical agents arising from work activities whether the risks are to people at the workplace or outside of it."

The British Occupational Hygiene Society (1980) published an outline of the remit of occupational hygiene:

- identification of harmful, unpleasant or uncomfortable factors (chemical, physical, biological, ergonomic or psychological);
- measurement of relevant factors;
- interpretation of results and appraisal of risks;
- control measures;
- education;
- research and development.

It is useful to separate the knowledge domain of occupational hygiene from the range of professionals working full-time or part-time in this subject area. Occupational hygienist is the term generally used to describe the professional individual who spends much of his or her time concerned with 'occupational hygiene' issues. Of these, it is estimated that, in the UK, there are currently about 500 (taking into account all grades of the IOH in 1996), and over the last five years total numbers have been relatively static. Many more individuals, such as safety practitioners, occupational physicians and nurses are involved part-time in OH activities, ie, concerned with the application of occupational hygiene principles, than are represented on the IOH membership list. This was illustrated by Hale, Piney and Alesbury (1986) who compared the membership of the British Occupational Hygiene Society with that of the Institute of Occupational Hygienists (IOH).

In the USA, the characteristic full-time industrial hygiene (IH) professional has been described by the American Industrial Hygiene Association (AIHA) as:

> "..... a person having a college or university degree or degrees in engineering, chemistry, physics, medicine, or related physical or biological sciences, who by virtue of special studies and training must have been sufficient in all of the above cognate sciences to provide the abilities 1) recognise the environmental factors and to understand their effect on man and his well-being; 2) to evaluate on the basis of experience and with the aid of quantitative measurement techniques, the magnitude of these stresses in terms of ability to impair man's health and well-being; and 3) to prescribe methods to eliminate, control or reduce such stresses when necessary to alleviate their effects."

2.6.1 HISTORICAL DEVELOPMENT OF US INDUSTRIAL HYGIENE

The origins of occupational hygiene can be directly traced to the USA of the early decades of this century. The discipline was transplanted to the UK in the years after the Second World War by some key pioneering individuals. This resulted in a learned society, the British Occupational Hygiene Society, being founded in 1953. The UK Institute of Occupational Hygienists was founded in 1975 and the British Examining and Registration Board in Occupational Hygiene (BERBOH) in 1978.

Corn (1978) reviews the history of US industrial hygiene and identifies two key conceptual changes occurring this century, which help to explain the specific development of the discipline of industrial hygiene in the United States. First, the idea that prevention and control of hazards on the job can minimise or even eliminate risk, slowly replaced the view that accidents and disease were the unavoidable by-products of work. Second, the assumption of responsibility by government for the health and safety of workers slowly replaced the more extreme laissez-faire views of the early years of this century, when statutory regulation was regarded as an unnecessary interference in industry. Hewitt (1983) comments on the generous funding by the US Government of IH activities during World War Two, which in the early 1950s, resulted in the release of a well trained corps of hygienists into private companies. Both Hewitt (1983) and Piney (1990) comment on the important role of US insurance companies in the development of American industrial hygiene.

Industrial hygiene has never been a single professional activity. In the early days, it was primarily physicians who practised 'industrial hygiene', and Corn (1983) specifically identifies physicians, chemists, nurses, statisticians and engineers as collectively contributing to the achievements of industrial hygiene. Late 19th/early 20th century articles in the Journal of the American Public Health Association refer to 'IH activities', which were carried out by men and women in a number of health disciplines, since at that time IH as a profession did not exist. Piney (1990) notes that the early definition of industrial hygiene was medically-oriented towards sick people. Corn (1983) identifies three important historical periods in the development of American IH, namely, 1900-1917, 1933-1946 and 1969-1970.

2.6.1.1 US Developments 1900-1917

From 1900-1917 the laissez-faire approach was still the dominant view of the world in the USA. In 1913 there were 23,000 occupationally-related deaths from a total US workforce of 38 million. Forces for change initiated what Corn terms a 'safety movement' and an 'industrial hygiene movement'. These progressive groups also sought workmens' compensation laws for at this time responsibility for accidents was beyond the control of workmen and survivors

received little or no compensation. According to Corn (1983), a few socially-conscientious physicians realised that occupational disease did not receive adequate attention. She mentions in particular the physician Alice Hamilton, who carried out a wide-ranging survey, which helped to define and describe the major problems of US occupational health hazards at that time.

2.6.1.2 US Developments 1933-1946

Piney (1990) observes that the sanitary and chemical engineers, who became IH practitioners in the 1920s and 1930s, used engineering and organisational skills to control exposure to toxic substances. At the same time the practitioners of another newly-emergent scientific discipline 'industrial toxicology' were attempting to develop the required environmental criteria (ie, exposure tolerability standards). Piney (1990) analyses the subject content and author specialism of the US Journal of Industrial Hygiene over the period 1919-1939. He notes a clear transition from what he describes as 'medical IH' to 'non-medical IH' over this period, observing that IH in 1940 was 'a far more complex and multi-disciplinary subject area than it was in 1920'. By 1940, the majority of people who worked in industrial hygiene were not medically-qualified. At this point, the strategic approach of recognition, evaluation and control of 'factors' (ie, identification of hazards, assessment and control of risks by another name) had real meaning.

In 1936 the US Journal of Industrial Hygiene became the Journal of Industrial Hygiene and Toxicology, exemplifying the close relationship between these two newly emergent specialisms. Industrial toxicology offered the possibility that hazards could be identified before they were introduced into the workplace and further that 'thresholds' could be found which would represent 'acceptable' or 'tolerable' levels of exposure to substances and other hazards. This would then provide the rationale for workplace environmental standards. This close relationship of the two developing specialisms is symbolised in the title of Frank Patty's seminal book 'Industrial Hygiene and Toxicology', first published in 1948.

Following President Franklyn Roosevelt's 'New Deal', advances in US social legislation spilled over into occupational health. Responsibility for safeguarding safety and health remained with state and local governments whilst Federal agencies concerned themselves primarily with the dissemination of information and research. At this time Federal funds were made available for industrial hygiene activities in local and state health departments in order to:

> ".... promote industrial hygiene in all its aspects and phases, and to co-ordinate such activities in official federal, state, local and territorial organisation."

Regarding this state of affairs, Patty (1958) comments that:

> "Under the stimulus of additional Federal funds allocated to states and territories, the development of official industrial hygiene agencies reached an all time high in 1949 and included all but two of the states."

The development of industrial hygiene did not go unnoticed in the UK, and Patty (1958) cites Merewether, a Senior Medical Inspector of Factories, as recognising the lack of (occupational health) engineering interest and skill in England and conceding American leadership in this area during an address to the American Public Health Association in 1942. Merewether told the audience that the time had arrived when:

> "... the doctor no longer knows everything about everything."

This was a reference to the continuing dominance of the 'medical phase' in contemporary occupational health in the UK. He urged the 'English chemists' to instigate the formation of a society for:

> "The holding of annual conferences and the publication and distribution of papers and literature on the subject of industrial health and safety."

2.6.1.3 US Developments 1969-1970

The American public learned that factories and mines were still dangerous places through the public testimony given to hearings prior to the enactment of the Federal Occupational Safety and Health Act in 1970. This demonstrated that although there was sufficient knowledge to prevent many occupational

diseases, this knowledge had not been effectively applied in practice. Safety and health laws had generally been left to individual States and were piecemeal, of variable quality and often not enforced. The complexity of American industry with its sophisticated production processes and use of new chemicals pointed to the need for research into hazardous agents and their control, nation-wide reporting of health and safety statistics and Federal legislation (Corn, 1978). The 1970 Occupational Safety and Health Act clearly designated health and safety in the workplace as the responsibility of the employer. Further and importantly, the Act stimulated interest in workplace hazards in both public and the working population. There was a surge in membership of both the AIHA and the ACGIH, for example the AIHA grew from 1600 members in 1968 to 8900 in 1991.

The table below summarises the development of US industrial hygiene:

Table 2-1 Landmarks in US Industrial Hygiene	
1912	New York State sets up a Department of Industrial Hygiene;
1913	US Public Health Programme sets up an Office of Industrial Hygiene and Sanitation;
1914	American Public Health Association - Section formed on Industrial Hygiene and Sanitation;
1918	Harvard Medical School established a Department of Applied Physiology and shortly afterwards a department of Industrial Hygiene; This was to provide instruction in industrial hygiene to medical and science graduates;
1938	The National Conference of Governmental Industrial Hygienists is formed. This is now known as the American Conference of Governmental Industrial Hygienists (ACIGH). At formation IH practitioners from private companies were not allowed to join;
1939	American Industrial Hygiene Association (AIHA) formed, which allowed IH practitioners from industry to join. Published 'IH Quarterly' the first journal devoted to IH, and which became the American Industrial Hygiene Association Journal in 1957;
1949	Annual reports cited from 45 industrial hygiene agencies in 38 US states;
1968	AIHA 1600 members;
1970	Occupational Safety and Health Act 1970
1981	AIHA 5500 members; CIH 1700
1991	AIHA 8900 members; CIH 4000

(1953 British Occupational Hygiene Society founded

1992 BOHS had a listed membership of 1132; UK Institute of Occupational Hygiene had 517 members in total).

2.6.1.3.1 Key publications related to hazardous substance risk assessment

For many years the developing expertise of the American hygienists has been reflected in the growing body of publications related to various aspects of hazardous substance risk assessment. As illustrative examples, for many years

the ACGIH itself, has published the following seminal works: *Air sampling Instruments* (7th Edition 1989) first published in 1960, *Industrial Ventilation – A manual of recommended practice* (21st Edition 1992) first published 1951 and *Threshold Limit Values – for Chemical Substances and Physical Agents* (published annually).

2.6.2 OCCUPATIONAL HYGIENE IN THE UK

In the years prior to the formation of the British Occupational Hygiene Society (a learned society) in 1953, occupational hygiene did not exist as a recognised discipline in the UK. Aspects of what is now recognised as occupational hygiene were, however, practised in some establishments, principally university departments and research institutes. Contemporary research topics, cited by Hickish (1993), were principally concerned with measuring air contaminants and included lead, cotton dust, vanadium and coal dust. Industrial research associations were involved in devising methods of controlling dust exposure in the iron & steel and pottery industries amongst others. Physical hazards such as abnormal atmospheric pressures and extreme thermal environments were also under active study at this time. In these activities the basic occupational hygiene concepts of recognition, evaluation and control, although not explicitly defined, were being applied and techniques were being developed which would form the basis of future occupational hygiene practice.

2.6.2.1 British Occupational Hygiene Society

This Society has been the body which has been most influential in the development of British occupational hygiene. The formation of the Society in 1953 provided the opportunity for those practitioners of occupational hygiene to meet together and begin to recognise the broader aspects of the developing profession. The objective of the society was: 'To promote the science of occupational hygiene.' According to Hickish (1993) practitioners who:

> ".... had previously regarded themselves as engineers, chemists, physicists or physiologists engaged in some sort of industrial medicine related activity began to realise that they were members of a common fraternity with a common purpose – the recognition evaluation and control of hazards to health in the workplace."

However, in terms of universal recognition of the distinctive approach of occupational hygiene there was still a long way to go. At the first conference of the BOHS , in November 1953, Walter Monckton, the then Minister of Labour and National Service, stated:

> "The prominence now being given in Government and other quarters to the development of provision for occupational health in its widest sense shows that occupational hygiene is a subject which will receive increasing attention. It is particularly opportune that the foundation of this Society should come at a time when efforts area being made to establish and develop this important service to industry."

But, he then went on to discuss occupational health *entirely* in terms of the incidence of disease, without any reference to environmental conditions. The Chief Inspectors' of Factories reports over this period show a similar general bias. For example, the 1947 report discussed occupational health matters under the heading 'Industrial Diseases'. The subsequent review is almost exclusively in terms of industrial disease and industrial poisoning statistics. There is very little reference to the quality of the working environment. Under the heading 'Asbestosis and Carcinoma of the lung' there is a comment about exposure to asbestos dust.

> "An attempt was made to classify the cases according to dustiness of occupation. This had to be abandoned owing to the frequency with which workers are transferred from process to process and to the fact that dusty and less dusty processes are often carried out in close proximity."

This quote reflects the lack of personal sampling methods to evaluate worker asbestos exposure at this time. Such monitoring methods were central to the later development and expansion of occupational hygiene. Similarly, contemporary reliance on subjective methods of evaluation is cited by Murray (1993), who, when writing about this period, comments regarding the enforcement of Section 47 of the 1937 Factories Act (dealing with practical measures to be taken to protect workers against the inhalation of dust or fume):

> "As inspectors, we attempted to ensure compliance with this section of the Act by using our five senses, coupled with the sixth sense that every good factory inspector has ...."

He adds that although there were some developments in air monitoring techniques, this was still mainly at a research stage and little was done on a regular basis. Of a visit to the US in 1954, Murray wrote:

> "The most important aspect of American industrial health is ... the employment of industrial hygienists. They are usually men with a chemistry, physics or engineering background employed on a full-time basis to investigate health risks in industry."

and:

> "There is no comparable body of men, or mass of equipment in this country. Part of the reason may be that the American industrial hygienist uses the philosophy of maximum allowable concentrations. Insurance-company practice and state law is based on these figures and the need for their measurement may be one reason why such a large amount of equipment is provided. It is nevertheless a matter of some envy that the American is able so well to assess the industrial environment."

Jones (1993) observes that from the mid-1950s onward, progress was rapid in devising methods of detection, measurement of substances causing environmental contamination, development of instrumentation, accurate assessment and recording of pathological effects, and methods of prevention. In most instances this was for linking occupational causes to observed health effects.

2.6.2.2 *Activities of the British Occupational Hygiene Society*

The aim of this section is to examine the development, activities and published output of the Society and its members, in order to demonstrate that a central concern has always been with evaluating exposure to toxic substances, deriving tolerability standards and developing preventive measures.

The activities of the BOHS may be categorised as:

- developing air monitoring methods and expertise in exposure assessment;
- setting standards for occupational exposure;
- the development of technical standards;

- organising conferences, meetings and international symposia;
- publishing a learned journal - *The Annals of Occupational Hygiene;*
- providing education and training;
- ensuring/advocating professionalisation of occupational hygiene;

Each of these aspects will be considered below:

2.6.2.2.1 Development of air monitoring methods and expertise in exposure assessment

A crucial aspect of evaluating the work environment has been the development of monitoring methods, particularly in the case of airborne chemical substances in view of the number and variety of materials in use. The need for the development of methods for qualitative and quantitative assessment of air contaminants has been a key impetus to much occupational hygiene work over many years. A brief content analysis of BOHS's scientific journal *The Annals of Occupational Hygiene* illustrates this point, showing a high incidence of papers dealing with such method development. This concern dates from the earliest days of the Society; indeed, the second conference, in 1954, was entitled *'The Investigation of Atmospheric Contaminants in Factories.'* This focus on workplace exposure assessment continues to the present day and is exemplified by the recent publication of two important reference books by working groups of the BOHS (Hawkins *et al.*, 1993) and the AIHA (Guest *et al.*, 1993). Burgdorf (1993) asserts that these books reflect:

> "the state of the art in monitoring airborne contaminants."

Further, that they contain detailed accounts on the design of an appropriate measurement strategy, the implementation of sampling protocols, the interpretation of exposure data and recommendations, which are likely to be effective.

In the mid-1960s the 'Group of Practising Occupational Hygienists' (GOPOH) was formed as an *ad hoc* sub-group within the BOHS, a group who produced a

'Manual of sampling instruments'. The availability of commercial sampling instruments at this time was still very limited, and this volume, albeit slim, gave details of the equipment available and critical experiences of its use. In 1969, the Technology Committee of the Society decided that the production of a comprehensive *'Directory of Monitoring Instruments and Analytical Techniques'* was not considered practicable in view of the already available publications of the ACGIH.

2.6.2.2.2 *Setting standards for occupational exposure*

King (1993), relates his personal experience of the late 1940s/early 1950s with the problem of quartz-bearing dusts in foundries. At this time there was no air quality (tolerability) standard for exposure and no valid air sampling method. By the mid-1950s, improved methods of sampling for respirable mass had been developed, and some researchers found that steel foundry pneumoconiosis did not occur where exposures were less than 0.1 mg m^{-3}. According to King (1993) 0.1 mg m^{-3} quartz was used as a standard in the South-East of England and GOPOH proposed its wider use for the control of foundry quartz-bearing dust.

Further, according to King (1993):

> "At the same time we were equally lacking a standard for asbestos, with the USA still counting 'particles' as for the other fibrogenic dusts. By the later 1950s in the London area at least, a figure of 0.1 mg m^{-3} was in use."

In the late 1950s/early 1960s a 0.1 mg m^{-3} limit was being used to control asbestos exposure. A Society Standards Committee was created in 1965 and it was decided that the first major objective was a standard for asbestos:

> ".... an analysis of the data available relating the risk of disease to exposure and from this recommending standards, that the sub-Committee concerned, considered to be an acceptable compromise between risk and practicability."

The Standards Committee went on to developed standards for chrysotile and amosite asbestos dust, cotton dust, flax, and wide band noise amongst others.

The aim was to relate exposure data to health-outcome data being as 'scientific' as possible. This Committee had to decide on an exposure level acceptable to the workforce as a whole. The Committee had some difficulties with this role since most of the members were occupational hygienists and members of companies who would have to comply.

Indeed, over the years there has been much criticism of the role of the BOHS and its standards and that the Society showed favour towards the needs of industry. Referring to the British asbestos standard (BOHS) of 2 fibres/cc and the American standard of 5 fibres/cc, Stellman & Daum (1973) comment:

> "There is already scientific evidence to indicate that these standards are inadequate to protect workers from asbestosis."

Further the standard did not take into account the carcinogenic effects of asbestos and a working lifetime of 25 years ("50 fibre years") was used in the calculations. This 'tolerability' standard was intended to protect 99% of those exposed to 50 fibre-years of asbestos from asbestosis (ie, allow harm in 1% of this population). The BOHS standard for wide band noise exposure was similarly criticised for using a short 'working lifetime' and again a 1% level of harm, even though the working population exposed to loud noise at the time was much larger than that exposed to asbestos dust.

Over the years the Committee has had various terms of reference and Turner (1993), a previous Chairman commented:

> "It is evident that more standards must be prepared if the Society intends to continue to produce them for substances where the greatest need is apparent."

However, in 1978, it was decided that the Standards Committee should become a 'dose/dose response' definer only, and in 1979, that the Committee should not produce standards as such, but produce the 'basis for an occupational limit'[2]. From this time on the Committee seems to have drifted into more of a

[2] This meant that the Committee would confine itself to the scientific aspects a developing information on dose-response relationship (the basis for setting standards) and leave to others

reactive role in preparing comments on proposed standards. Today, standard setting is carried out in the UK, by the Advisory Committee on Toxic Substances (ACTS) following the HSE's published Indicative Criteria (HSE, 1996). These standards are deemed to represent 'adequate control', and form part of the requirements for compliance with the COSHH Regulations and they are published as a list (HSE, 1997). Apart from the representation of individuals on ACTS, the BOHS Standards Committee has no current role in proposing exposure standards.

Overall, the Standards Committee has produced twelve publications in *The Annals of Occupational Hygiene* (Turner, 1993) - nine relate to standards for specific toxic substances (chrysotile asbestos (BOHS, 1968, 1973, 1983), amosite asbestos (BOHS, 1973a, 1983), flax dust (BOHS, 1980), cotton dust (BOHS, 1972), cadmium oxide fume (BOHS, 1977), diesel fume (BOHS, 1981) and trichloroethylene (BOHS, 1974)), one to wide band noise (BOHS, 1971), one to the methodology of standard setting (BOHS, 1976) and finally, an overview of the work of the Committee (BOHS, 1991). The predominant concern of the Committee has been its work on exposure to toxic substances.

2.6.2.2.3 Technical standards

A technical committee was set up by the BOHS in 1966 and members of the GOPOH sub-group were prominently represented. Its (rather broad) terms of reference were:

> "To be responsible for maintaining a collection of current information on all aspects of occupational hygiene practice."

There was pressure to publish a prepared *'Instrument Directory'*, which critically reviewed some of the then available instrumentation. This was eventually distributed privately as a GOPOH publication solely for its

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(the HSC's tripartitieAdvisory Committee on Toxic Substances (ACTS)) to decide what adopted value was 'reasonably practicable' for the UK to achieve. This was, in effect,to adopt a particular numerical value and make the compromise between protection of health and the costs of any further reduction.

members. In 1968 the Committee was reformed as the 'Technology Committee' and given new terms of reference:

> "To formulate, validate and recommend procedures and techniques for the appraisal and control of the working environment"

A programme of work was started, again reflecting a strong bias of interest towards the assessment and control of air contaminants. This included the drafting of standards for fume cupboard design, production of standard gaseous atmospheres and methods of testing detector tubes and the calibration of their pumps. A *Directory of Monitoring Instruments* and a *Directory of Analytical Techniques* were deemed not to be practicable.

As with the Standards Committee, the predominant concern of the work of the BOHS Technology Committee has been the evaluation and control of toxic substances. The Committee has produced thirteen publications - ten relate to toxic substances (seven describe various aspects of techniques for evaluating air contaminants (BOHS, 1973, 1983, 1983a, 1984, 1985, 1985a, 1985b, one deals with standard biological reference data (BOHS, 1992) and two deal with control of air contaminants (BOHS, 1975, 1987). The remaining three publications are concerned with the design of hearing protectors (BOHS, 1979), the thermal environment (BOHS, 1996) and application of statistics in occupational hygiene sampling (BOHS, 1989).

2.6.2.2.4 Conferences, meetings and international symposia

When the BOHS was established, one of the early priorities recognised was the:

> ".... establishment of regular conferences and meetings at which developments in the field could be presented and discussed, and of a reputable journal in which they, along with other papers, could be recorded, were major priorities."

A substantial majority of conference title themes and papers again concerned the evaluation and control of airborne chemical contaminants.

Commencing in 1960, there was the first of a series of what were to become quinquennial international symposia on *'The Behaviour of Inhaled Particles and Vapours.* This series of symposia has given the Society a high profile and world-wide credibility in this particular topic. However, over the years, the

majority of papers have been concerned with 'particles' and not 'vapours'. (From the first four symposia 219 papers were read in total, with 207 on particles, nine on vapours and three on particle-vapour interaction). Amongst other related topics, sampling methods and standard setting has been extensively covered in this context. The symposia series commenced in April 1960 and the most recent was held in 1996 in Cambridge, where there were eighty short presentations and sixty poster displays. Coal and silica featured strongly, but the forty papers on fibres indicated a continuing and strong interest in this class of particle.

2.6.2.2.5 *The Annals of Occupational Hygiene*

One of the earliest acts of the Executive of BOHS in 1953 was to acknowledge the need for a journal as soon as was practicable and the *Annals of Occupational Hygiene* commenced publication in 1958. One purpose of the journal was to report conference proceedings in a formal manner. A motivating influence in the development of a journal was that it would enhance the Society's influence and reputation. In the original agreement between the Society and Robert Maxwell for Pergamon Press to publish the Annals it was stated:

> "It is hoped that less than fifty percent of the articles shall be of a medical nature, preferably not more than twenty-five percent."

To some extent this reflected a view among some members of the Society who were determined not to be swamped by medically qualified members, and to highlight the non-medical aspects of the occupational hygiene approach. Nevertheless, in 1960, within the Executive Committee, there was some criticism that there were too many articles of a medical nature and not enough on occupational hygiene. Another recurring criticism was the apparent shortage of more practical papers in the Annals. Successive editors have responded to such criticisms by asserting that they can only publish what is submitted and that it is difficult to get practitioners to submit articles about their work.

A selective content analysis of the Annals (1982 and 1992) revealed that a significant number of contributions dealt with issues on hazardous substance risk assessment and control, particularly with the design and development of air monitoring techniques and equipment. This is to be expected that a

Society's journal would mainly reflect its members particular interests and expertise.

2.6.2.2.6 *Education and training committee*

The BOHS set up an education committee in 1978, partly as a result of the unease of various university departments (which offered courses with an occupational hygiene content) about their lack of recognition by the British Examining and Registration Board in Occupational Hygiene (BERBOH). The argument taken by the BERBOH, was that possession of a degree did not confirm the professional competence that resulted from experience (which it maintained was inherent in its awards). In 1985, the *Education and Training Committee* reacted to the implications of the then proposed COSHH Regulations, by compiling a booklist, and preparing a list of people who were available to lecture on the implications of COSHH and its implementation. At this point in time, the Committee opposed the Society sponsoring COSHH training courses.

However, this view later changed and it began to draft programmes for appropriate courses. Turner (1993), asserts that a probable reason for this initial reluctance was the teaching establishment affiliations of a majority of the Committee at this time.

2.6.3 PROFESSIONAL OCCUPATIONAL HYGIENE

The development of a profession often follows this general pattern (Hale, Piney *et al.* 1986):

- the formation of a society of practitioners:
- the establishment of a professional journal and subsequently:
- the provision of professional qualifications by which competent practitioners can be recognised.

By 1967, the BOHS was a well established society and *The Annals of Occupational Hygiene* was an acknowledged high quality journal. However, at

this time there was no formal professional UK occupational hygiene qualification. Membership of the Society was open to all who had an interest in occupational hygiene and as not all members were working in full-time occupational hygiene BOHS membership could not be regarded as an indicator of professional competence. The Society established the British Examining and Registration Board in Occupational Hygiene in 1967. In 1978 having developed a registration function for 'competent persons', it became the British Examining and Registration Board in Occupational Hygiene. In 1991 this merged with the Institute of Occupational Hygienists and its name reverted to British Examining Board in Occupational Hygiene (its registration function passing to IOH). The principal aim of the Board was:

> "to establish recognised standards of competence in the practice of occupational hygiene."

At an early stage two levels of attainment were envisaged, namely a senior professional grade (those capable of independently practising comprehensive occupational hygiene) and a more junior technical grade (those engaged in carrying out occupational hygiene measurement under the direction of a senior hygienist). The two awards became, respectively, the Diploma and the Certificate of Operational Competence in Comprehensive Occupational Hygiene. By 1975, the need for a lower level qualification was recognised. A significant number of people were carrying out occupational hygiene activities over a limited area of the field (for example, air sampling and analysis as part of their employer's compliance with legal regulations).

Syllabuses were originally prepared for thirteen sections of the comprehensive practice syllabus including toxic metals, harmful dusts, liquids, vapours, gases and mists, asbestos sampling and analysis, general principles of workplace control, noise and vibration, thermal environment. The predominant course material dealt with the evaluation and control of risks from toxic substances. C onsiderably less material dealt with risks from other health hazards. Following successful completion of a short course, a *Preliminary Certificate*, was awarded. Although these are being phased out (by August, 1997), the current list of subjects covered by *Preliminary Certificates* is given below:

- Microbiological dangers of occupations
- Noise and vibration
- Thermal environment
- Ionising radiation
- Lighting and non-ionising radiation
- Asbestos
- Principles of making assessments under the COSHH Regulations
- Assessment of Workstations with Display Screen Equipment

'Core' modules have recently been introduced to replace the *Preliminary Certificates*. (BEBOH, 1995, 1996). These are available for:

- Occupational hygiene foundation
- Risk assessment
- Hazardous substances
- Measurement of hazardous substances
- Workplace control
- Physical agents

This list of 'core' modules retains the bias towards toxic substances, their hazards/risks and control. (Further specialist modules are available for study/examination from September 1997. These include: Asbestos; Noise and vibration; Pesticides and Pharmaceuticals; Thermal environment; Ionising radiation; Microbiological risks; Lighting and non-ionising radiation; Environmental pollution.)

2.6.3.1 *The Institute of Occupational Hygienists*

There were various attempts within BOHS to cater for the special needs of career occupational hygienists as well as for members from other specialist disciplines. However, by the mid-1970s there was a growing demand from a significant number of practising hygienists for a body that would exclusively represent their views, interests and standards. This was something which they felt the Society was not able to do effectively, since membership was open to all with an interest in occupational hygiene, irrespective of background or other professional affiliations. As a result of these sentiments and the tactics of a core group of hygienists, the *Institute of Occupational Hygienists* was formed in 1975. As part of it's activities, the Institute has produced various publications including guidance for members on protocols for assessment of health risks, with particular reference to assessments made under the COSHH Regulations (IOH, 1989). In 1995, the Institute of Occupational Hygienists had 517 members in all grades (IOH, 1995). This breaks down to Honorary Fellows 9; Fellows 42; Members 142; Licentiates 150; Graduates 70; Associates 55; Affiliates 20; Students 17; Retired 12.

2.6.3.2 *Employment of professional occupational hygienists*

Occupational hygienists are directly employed in larger companies in a variety of industries, for example, in the automotive oil and chemical industries. They are also employed by HSE as specialist occupational hygiene inspectors. However, many smaller companies cannot afford to employ a full-time occupational hygienist and these occasionally engage the services of an occupational hygiene consultant. The IOH produces annually *The Directory of Occupational Hygiene Consultants* and the 1995 edition lists 42 consultancies. All consultancies listed, must employ at least one professionally qualified occupational hygienist, who is a corporate member (Fellow or Member) of the Institute. Of the 42 consultancies listed, 41 of these list *COSHH assessments* and *air sampling* as part of their capabilities. (The remaining consultancy listed, offers only environmental assessment services.)

2.7 CONCLUSION

The above examination of the activities and publications of the BOHS, BEBOH and IOH has demonstrated, that concern with toxic substance exposure evaluation and control has been paramount. This has been shown with occupational hygiene and hygienists taking the lead in:

- developing and improving air monitoring techniques;
- the derivation of air quality standards for occupational exposure;
- the development of technical standards related to toxic substances;
- the balance of content in conferences and the Society's learned journal;
- the Society's seminal role in holding a series of quinquennial;
- international symposia on 'inhaled particles and vapours';
- courses and examinations defining occupational hygiene competence developed by BEBOH, which have a high subject content relating to toxic substances.

Overall, it can be seen that occupational hygiene and its practitioners can claim to be the key repository of the requisite expert knowledge and skills relating to hazardous substance risk assessment. As Roach (1992) suggests:

> "Occupational hygienists make professional judgements about the state of hygiene in workplaces. They make appraisals of employee exposure to chemical and physical agents sentiently, supplemented where necessary by actual measurements. This is at the heart of occupational hygiene."

On this basis, it is the occupational hygiene discipline and the hygienist that has been the primary initial target for this research into hazardous substance risk assessment. It is here that knowledge elicitation techniques have been initially applied to elicit details of this expertise.

3.

General aspects of expertise

3.1 INTRODUCTION

Chapter One developed perspectives on the UK occupational health problem and highlighted the current need for expertise in HSRA. Chapter Two outlined the basic concepts of HSRA and established occupational hygiene and occupational hygienists as the key repository of this expertise. Because of a demonstrable a lack of human experts, there is a need to distil this knowledge in order to structure it for non-experts. In order to achieve this objective, a key task is to review the literature on general aspects of expertise, its methods and findings, as a foundation for this study. The methods that have been used for knowledge elicitation (KE) ie, the extraction of knowledge from human experts are particularly relevant here.

In a broader context, the development of KE techniques has been driven by, interest in, and demand for, 'thinking' computers (expert systems). The elicitation of human expert knowledge has been a bottleneck in the development of such systems (Hayes-Roth et al., 1983). This research is primarily concerned with the elicitation of HSRA expertise and the development of improved training and (HSRA) 'aids' (at this point non-computerised) to assist non-experts charged with this task.

There are various reasons for wanting to develop expert aids in a given subject domain, including:

- the inherent complexity of a particular problem subject area;
- a lack of available human experts;
- the expense of using human expert consultants.

The above criteria apply in this domain and support the development of aids for HSRA. A wide range of HSRA aids have already been produced both commercially and by individual organisations, which are designed for their own in-house requirements. For example, a computerised expert system, which carries out HSRA on a limited in-house basis, has been developed by British Gas plc. for management training purposes (Kirkwood *et al.*, 1989). The knowledge in this system was elicited from the company's occupational hygiene group by a series of personal interviews and group discussions (Colby, 1992). Further, the WORKSPERT expert system for workplace exposure assessment has already been discussed in Chapter Two (Tait, 1992).

Other types of aid developed for assisting HSRA and broader toxic substance management include:

- substance hazard data forms;
- computerised databases containing hazardous substance information;
- record-keeping systems;
- auditing systems;
- training packages including manuals and videotapes;
- generic risk assessment forms;
- technical monitoring equipment;
- textbooks and guides.

In a broader context, Hondros (1991) reviews the application of expert systems across the field of occupational health and safety and identifies systems in the following areas - generic safety analysis; manual handling; designing lifting tasks; physical work stress analysis, heat stress evaluation and respiratory protection selection. Further, a range of expert systems have been developed in the environmental impact area of risk assessment and these are reviewed by Hushon (1990).

3.1.1 EXPERT SYSTEMS

The development of expert systems has led to a better 'systematisation' of knowledge in various subject domains (Bensiali, 1987). Knowledge can then be made more widely available and more effectively used particularly in training. According to Cordingley (1989), there is no core theory for KE despite its fundamental importance to expert system development. It is common for human experts to find it difficult to explain their problem-solving approach and this leads to problems with knowledge elicitation.

Expert systems are computer programs which are intended to solve real world problems achieving the same level of performance as human experts. Expert system programs *reason* using knowledge as compared with traditional computer programs which *calculate* using data. By reasoning is meant using some form of logic. This reasoning ability is combined with a significant body of knowledge in a particular subject area or domain. Feigenbaum (1989) uses the term 'knowledge' to mean 'facts plus know-how' in a particular subject domain. An expert system consists of three fundamental parts:

- a knowledge base;
- a control structure or inference engine and;
- a user interface.

According to Slatter (1987), the knowledge base contains factual and heuristic knowledge, the latter incorporating some subjective judgement. The inference engine is the reasoning or problem solving part of the system. During its reasoning it uses data obtained either from the knowledge base or provided by the user of the system. The engine may use data in different ways including 'forward chaining' (inductive or data-driven) or 'backward chaining' (deductive or goal-driven) modes. The reasoning process continues until a definite diagnosis or recommendation is given.

There is now a brief review of ideas and concepts concerned with the generic aspects of expertise and problem-solving followed by a discussion of knowledge elicitation methods.

3.2 CHARACTERISTICS OF EXPERTS AND EXPERTISE

Much of life is about problem solving – we are solving problems at every turn in domains that are highly familiar, for example, communication by speaking a language, driving a car, crossing the street. Imagine a person from the Victorian era transplanted to the centre of a modern city and the scale of the problems they would face. Extremely fast unfamiliar type of traffic, partly controlled by a system of coloured lights and unfamiliar signposts. Compounded with this is the fact that the traffic may not show consistent adherence to the directions given in these controlling devices. These would obviously be very difficult and dangerous problems for our transplanted Victorian. However on the whole, with the exception of young children and old people, problem solving in this domain for most of us is almost automatic, since we have learnt successful methods of achieving our goals. We would probably not recognise that we are solving a problem. Through practice we have become relatively expert.

There are also of course, more specialised areas of problem solving, for example, playing chess, flying aeroplanes, carrying out scientific experiments, working in occupational health and safety, or carrying out hazardous substance risk assessment. There appear to be many similarities between developing expertise in specialist areas and in the common domains noted above. Possession of skills and knowledge distinguishes the domain expert from the domain novice. An 'expert' is defined by Chamber's 20th Century dictionary (1977) as:

> "one who is skilled in any art or science – a specialist"

In a similar vein, the entry for the word 'expert' as a descriptor of someone or their activity is:

> "taught by practice; having a familiar knowledge; having a facility of performance; skilful; adroit"

The possession of 'expertise' is what makes an expert different from a non-expert and this is defined by the above source as:

> "expert knowledge, expertness"

(These terms originated from the Latin verb *expertus* - to try thoroughly.)

3.2.1 TYPES OF KNOWLEDGE

Winograd (1978) distinguishes two basic types of knowledge ie, 'declarative' and 'procedural'. Declarative knowledge refers to knowledge about knowing facts or things, for example, knowing that Paris is the capital of France or that the boiling point of water is 100 degrees Celsius (at one Bar). On the other hand, procedural knowledge refers to knowledge about performing various cognitive activities, for example, knowing *how* to drive a car competently or *how* to carry out a workplace assessment survey. In solving real problems it is primarily procedural knowledge that is being used.

3.2.1.1 Human expertise

Slatter (1987) lists some widely held general and largely questionable beliefs about human expertise:

- human expertise is acquired through experience;
- human expertise is something mysterious and inexplicable;
- the superior performance of experts is based on superior intellectual ability;
- experts reach conclusions by making a series of logical deductions based on available evidence;
- the problem solving skills of physicists and engineers is attributable to physical intuition.

Slatter (*ibid.*) also lists other more reflective beliefs about human expertise based largely on casual observation, introspection and findings from artificial intelligence studies:

- expert performance depends on large amounts of domain or subject-specific knowledge;
- experts know when a subject is outside their area of competence;
- experts can reorganise their knowledge into more appropriate forms;

- experts are capable of reflecting on their own cognitive processes and know about the state of their own domain knowledge;

- experts' reasoning is frequently inaccessible.

Similarly, Glaser (1988) asserts that the expertise research findings, listed below, are generic and applicable across the various subject domains that have been studied:

- experts excel mainly in their own subject domain, ie, expertise appears to be domain-specific;

- experts have a good deal of domain knowledge;

- experts perceive large meaningful patterns in their domains;

- experts are fast; they are faster than novices at performing tasks in their own domain and they quickly solve problems with little error;

- experts have superior short-/long-term memories in comparison to novices in their subject domain;

- experts see and represent a problem in their domain at a deeper level (recognising more basic principles) than novices; the latter tend to represent the problem at a more superficial level;

- experts spend a great deal of time analysing a problem qualitatively, and have strong self-monitoring skills.

With experts and novices operating in the health and safety knowledge domain, we can predict that the differences above would be present and influence problem solving performance.

In practical subject domains, specific physical attributes may also be important to expert performance, for example, the possession of good eyesight is vital for the flying of aeroplanes. However, in occupational health and safety and risk assessment we are primarily concerned with expert thinking or cognition. Physical attributes are unlikely to be significant beyond a reasonable level of

physical and mental fitness. Of course a keen sense of smell can be very helpful in HSRA and this aspect is discussed later in the experimental study.

3.2.1.2 Cognitive science and information processing

Slatter (1987) asserts that cognitive psychology only achieved a coherent identity in the 1960s. Prior to this, 'behaviourism' was the dominant school of thought with its emphasis on observable behaviour and animal-learning. experiments. Although in cognitive psychology there is no generally accepted unifying theory, most cognitive psychologists adopt a common approach based on an 'information processing' view of human cognition. An information processing system has a set of integrated receptors, memories, and effectors (Simon, 1979).

The study of expertise emerged as an identifiable area of psychological investigation in the late 1960s. This was largely due to developments in artificial intelligence and cognitive psychology. Interest focused on the study of expert-novice differences and particularly in the cognitive changes taking place during the transition from domain novice to domain expert. Expertise research is dependent on developments in other areas of psychology, particularly ideas on - memory, reasoning, learning and problem-solving. This is because expert-novice differences are observable in virtually all aspects of cognitive processing. As indicated above, both mundane and more specialist skills appear to have many developmental features in common.

3.2.1.3 Approaches to the study of expert cognition

Slatter (1987) identifies two general methods by which cognitive psychologists have studied expert cognition. The traditional psychological experiment involves proposing an experimental hypothesis from known theory. The next stage is to divide the subjects into experimental and control groups on the basis of their level of expertise. Finally, there is a test for significant differences between the groups. 'Protocol analysis' is a generic term for a number of different ways of assessing experts during problem-solving in their subject domain (See Section 3.3.1.3 below). A record is taken of what the expert or novice does (audio-tape, videotape or written). Typed transcripts are then

made from these records and the investigator tries to extract meaningful rules. The transcripts are then analysed for similarities and differences. Protocol analysis is often used to provide raw data for modelling cognitive processes under investigation.

The two approaches can be regarded as complementary, in that the traditional experimental approach is well suited to testing hypotheses about particular expert-novice differences, whereas protocol analysis can be used to model the transition from novice to expert. In the traditional psychological approach, the main variable of interest is the level of expertise of the experimental subjects.

The performance of experts (normally real specialists in a domain) and novices in a cognitive task is compared and sometimes people with intermediate expertise are also included (journeymen). Studies have ranged from using a few individuals to over one hundred subjects, although protocol studies have usually relied on much fewer subjects. A wide range of expert domains have been studied including - board games such as Chess, Go and Gomuku; mental calculation; algebra; physics; computer programming; and medical diagnosis (Slatter *ibid.*).

3.2.2 EXPERTISE RESEARCH FINDINGS

Slatter (1987) reviews research findings on expertise with respect to long-term memory, short-term memory and mental operations. Each of these has a direct parallel in computer expert systems, the development of which, has provided an impetus for much research in this area.

3.2.2.1 Long term memory

Experts have a superior long-term memory capacity to novices in their subject domain. This permanent knowledge of experts changes the more they learn about their domain. Rumelhart and Norman (1978) distinguish three modes of change, which can be regarded as overlapping:

- accretion - the quantitative accumulation of new knowledge within the framework set by existing memory structures;

- tuning - which is the slight adaptation of existing memory structures caused by normal variation of events within a domain;

- re-structuring - which involves a major re-organisation of memory structures, prompted by inefficiency and over-complexity in the existing structures.

Some features of this improved long-term memory observed in experts are illustrated below:

Facts

By attending lectures, reading textbooks, watching videotapes and other formal channels, experts accumulate a large store of factual information that can be used in problem solving. Medical students spend years assimilating information on human physiology and disease. This has been estimated at 0.5-1 million core facts in general medicine alone. Larkin (1980) estimates that a one year course in US high school physics, requires a student to learn about 300 'things' ie, physics concepts and laws from standard textbooks. (It is interesting to reflect on how many recognised 'things' or multi-subject concepts one would need to know in order to carry out a HSRA.)

Rules

DeGroot (1965) studied chess expertise using protocol analysis. Experts and novices were asked to speak aloud as they made their normal moves. There was little apparent difference between the two groups according to this analysis. In the next experiment, he asked players to reproduce a chess position after a 5-second viewing of a slide showing the twentieth move of a chess game. All the subjects were equally unfamiliar with the particular games, but they were the type of game that might be played by chess masters. Presumably this would give a slight inherent bias in favour of the expert group. However, striking differences in memory capacity were found between experts and novices. Experts were much better at reproducing the pieces of the game. They could reproduce on average about twenty pieces, while novices could only reproduce about five pieces.

Chase and Simon (1973) studied chess masters and found a similar situation. Subjects represented familiar groups of pieces as one unit (or 'chunk'). This grouping or chunking assisted them in their recall of chess patterns. However, this was only found to be useful with meaningful chess positions. It appears that chess masters build up patterns of familiar board configurations as a result of their extensive experience. Chase and Simon (*ibid.*) estimate that a chess master has spent a total of 10,000-20,000 hours staring at chess patterns. They do not remember the individual pieces but patterns. They conclude that it is reasonable to estimate that a chess master can recognise 50,000 different chess patterns. This is of a similar order of magnitude to the number of words a competent English reader may be able to recognise.

Chess masters appear to have stored the answers to many situations, which novices have to solve as novel problems. When experts and novices were presented with patterns of randomly arranged chess pieces, no significant differences were detected, and both groups could only reconstruct a few test pieces. This illustrated that experts do not have, in general, a superior memory capacity and when moving outside their domain expertise (in this case realistic chess patterns) their advantage disappears (Chase and Simon, *ibid.*).

Quantitative estimates of expert knowledge in a subject domain have been given in terms of the number of such rules acquired. Hayes-Roth (1985) estimates that a professional expert requires about ten thousand rules, with one hundred thousand representing the upper limits of human expertise.

This idea of superior expert memory for meaningful problems has been demonstrated in a number of other knowledge domains - the board game 'GO', electronic circuit diagrams, the card game 'Bridge' and in computer programming applications. This advantage is thought to be present in the working-memory as well as the long-term memory.

Production rules

Domain situations are thought to be represented as a pattern and recognition of patterns is thought to invoke stored knowledge about appropriate lines of action. 'Production rules' have been proposed to model expert skill-acquisition

of this kind (Larkin, 1980). Production rules are a theoretical construct, which have been useful in representing problem-solving. A typical problem-solving rule consists of a goal, some application tests, and an action. The following is a simple example of a production rule:

IF the goal is to measure the noise level accurately at the operator's ear position during normal work:

and the correct sound level meter is being used

and the meter is switched on

and the meter battery has been checked

and the meter has been calibrated

and the meter sensitivity has been adjusted to the appropriate scale

and the microphone is close to the operator's ear

and the operator is working normally

THEN record the noise level indicated on the meter display.

This production rule is organised into a condition and action. The condition acts as a statement of the goal (ie, to measure the noise level accurately at the operator's ear position during normal work) and certain tests to determine if the rule is applicable to the goal. If these tests are met, then the rule will apply and the action (recording the noise level indicated on the meter display) will be performed.

Object categories

Objects may be viewed at various levels of abstraction and it has been suggested (Slatter, 1987) that experts are capable of resolving finer levels of abstraction than novices. Experts are thought to have more lower-level categories, for example, a non-expert may regard sulphuric acid and carbonic acid as acids, whilst the expert chemist will regard them as a strong mineral acid and a weak organic acid respectively. According to Rosch *et al.* (1976)

experts are sensitive to more 'aspects' of domain situations, and Murphy and Wright (1984), propose that this results in 'fuzzy logic' in contrast to the 'crisp' ideas and concepts of novices. For example, a worker injured after removing a machine guard might well be labelled by a non-expert as 'careless'. However, to the experienced risk assessor, the presence of a badly designed guard, which interfered with production and consequent piecework bonus, the conclusion may be less straightforward. Here, the expert is more sensitive to the various situational factors that made the worker act as he did.

Mental Models

When performing a complex task, people are believed to access mental models which help guide their understanding and actions. In other words, problem-solvers learn to represent the problems in ways that enable more effective problem-solving 'procedures' to be applied. There is no agreement as to the exact nature of such mental models between researchers. However, domain experts appear to have access to more sophisticated mental models, when problem solving, than do novices. Experts learn to identify properties which are only implied in the surface features of a problem. This is useful because the deeper principles are more predictive of the method of solution. A shift in reliance on surface aspects to deeper features has been observed with developing expertise in various domains, for example, mathematics, computer programming and medical diagnosis. (Slatter, 1987)

Indexing Knowledge

Experts are faster than novices in performing tasks in their own domain. Speed of retrieval of knowledge increases with expertise and this can sometimes be almost instantaneous. This ability is believed to relate to the acquisition of a large number of perceptual patterns as 'chunks', which index part of an expert's knowledge store. With experience, experts learn to associate task-relevant knowledge with each pattern. Cognitive scientists have modelled the development of 'indexing' as the acquisition of production rules (discussed above). The condition part of the rule represents the indexing, a pattern which when matched evokes the attached action (knowledge).

Proceduralisation of Knowledge

The distinction has been made above between declarative and procedural knowledge. During skill acquisition, as expertise develops there is a shift from declarative to procedural forms of knowledge representation. Anderson (1990) presents a three–stage theory of skill acquisition:

- cognitive stage;
- associative stage;
- autonomous stage.

During the *cognitive* stage a description of the procedure is learned, people develop a 'declarative encoding', ie, they commit to memory a set of facts relevant to the skill. Learners rehearse these facts when they first perform the skill. At the *associative* stage a method for performing the skill is worked out. Learners use 'general' problem-solving procedures and facts previously learned about the task to guide this. Errors are gradually eliminated, the rudiments of more skilful behaviour developed and successful domain-specific procedures for performing the skill worked out. During the final *autonomous* stage the skill becomes more rapid and automatic. This can be regarded as an extension of the associative stage. Verbal mediation tends to decrease and may disappear altogether. This stage may last indefinitely and throughout the skill gradually improves. There is improvement in both speed and accuracy with practice. However, beyond a certain point the relative effects of practice rapidly diminish. 'Spaced' practice (with time) has been found to be more useful to increased skill than 'massed' practice. Knowledge of results is also important to subjects and they learn more rapidly if feedback on performance is given speedily.

3.2.2.2 Mental Operations

Experts are far better than novices about recalling facts about a domain and various explanations have been proposed to deal with this. 'Automatisation' of cognitive processes is believed to occur in the expert. This distinction between 'controlled' and 'automated' is now widely accepted. As noted above,

performance will benefit by practice but beyond a certain point by ever decreasing returns. Benefits of speed-up with practice have been noted where expert performance may be several times faster. At the same time experts also appear to develop a flexible control over their reasoning at a high strategic level. They can often see how a main task is decomposed into sub-tasks and the temporal relation between those tasks. As novices practice solving problems, they learn sequences of tasks to solve the problem or parts of the problem. This is referred to as tactical learning by Anderson (1990), who uses the term 'strategic learning' to refer to learning how to organise one's problem solving strategies.

Larkin (1981) looked at problem solving in physics. With set physics problems experts and novices applied particular principles in exactly the opposite order. A model, using a production rules framework, was developed to simulate the transition from novice to expert, which was observed with practice. Learners start out with 'productions' which reason backwards (goal-driven) and then slowly develop productions which make forward inferences. This did not hold for all domains since in computer programming both experts and novices developed programs in what is known as a top down approach, ie, they work from a statement of the problem to sub-problem to sub-sub-problem and so on. Novices seem to develop solutions depth–first whilst experts develop solutions breadth–first before moving down to the next level.

The transition from novice to expert does not appear to involve the same changes in strategy in all domains. Subject domains have varying structures that make different problem-solving strategies optimal. With the development of expertise in a domain, those strategies are discovered that are optimal for that domain.

3.2.2.3 Working memory capacity

Experts have larger memories for domain knowledge than do novices. One factor thought to be relevant here is the amount of information which can be stored in 'chunks', ie, experts are thought able store more information per chunk in the working memory than can non-experts. Other associated factors

are thought to be practice, automatisation of knowledge and directly retrievable long-term information.

3.2.3 CONCLUSIONS

There is a broad acceptance in cognitive psychology that for anything except the most rudimentary task, skilled human performance requires a flexible intermixture of forward- and backward-chaining of production rules. Many of the above findings relating to the development of expertise are apparently generic, ie, domain-independent. Therefore, it is likely that many of the above expert/novice differences would be found in problem solving in the health and safety or risk assessment context.

3.3 KNOWLEDGE ELICITATION

During the early stages of research into 'Artificial Intelligence' (AI) much effort went into discovering general principles of intelligent behaviour. The aim was to discover a *general* problem-solving strategy that could be applied to any human task. Feigenbaum *et al.* (1984), challenged the usefulness of this approach and proposed that experts possessed domain-specific problem-solving strategies together a with considerable amount of domain-specific knowledge. Attempts to incorporate these different aspects of domain knowledge resulted in the development of expert system computer applications. One of the biggest problems encountered here was eliciting the knowledge that human experts use in problem solving.

Domain information may be gathered from both human and non-human sources (for example, textbooks, technical manuals, photographs). It is usually necessary to consult a practising human expert since real expertise commonly derives from direct practical problem-solving experience. The gathering of information from any source is known as 'knowledge acquisition' whilst the collection of information from humans is known as 'knowledge elicitation' (Shadbolt and Burton, 1990).

The key question in knowledge elicitation is "How do we get experts to tell us what they do?" Much of the power of human expertise is acquired from many

years of experience taking the form of heuristics where 'rules of thumb' are invoked, which often (but not always), lead to a solution to the problem. This is in contrast to algorithms, which are general procedures guaranteed to result in the solution of a problem. The use of heuristics allows short-cuts to be used in the search for a solution. As discussed above much expertise knowledge becomes proceduralised and here it becomes difficult for the experts themselves to recognise exactly what they do or why in solving problems. It is important to improve the efficiency of knowledge elicitation techniques, reducing time and effort in spent collecting and analysing expert knowledge, including the time required with expensive experts.

3.3.1 KNOWLEDGE ELICITATION METHODS

A wide range of approaches have been tried with the aim of efficiently extracting the knowledge of experts and these are reviewed in the next section. Shadbolt and Burton (1990) believe that elicitation should always consist of a varied programme of techniques and methods.

3.3.1.1 The interview

This is the most common knowledge elicitation technique and a wide variety of forms of interview have been tried varying from the completely unstructured to the tightly-planned and structured session (Shadbolt and Burton, *ibid.*). One problem with the interview is that experts will only produce what they can verbalise and non-verbalisable aspects will not be captured.

The structured interview

This has the advantage that it provides structured transcripts which are easier to analyse than unstructured conversation. Cordingley (1989) asserts that, structured interviews are where the interviewer asks the same questions in the same words and in the same order for each interview. Many of the questions are 'closed', ie, questions where expected answers are short with few surprises and likely answers can be been formulated in advance. Structured interviews are useful when specific material is required and features of topics and responses can be anticipated. These are also used when wording and order of

questioning is felt to be important and where consistency across a number of interviews is required. These conditions are likely to apply in a large scale survey and where multiple interviews are conducted to fill in gaps in elicited knowledge and check the consistency of responses.

In contrast, Shadbolt and Burton (*ibid.*) give an example of what they call a 'structured interview format', which does not conform to the rigid definition outlined by Cordingley above. They give examples of 'probes' as a means of formalising the interjections of the interviewer, for example, 'Why would you do that?'

The unstructured interview

Unstructured interviews are designed to allow interviewees to cover topics largely in their own way. They provide a capacity for surprise for interviewers who have an idea of the kind of information that is needed and who are prepared with a set of *seed* questions, *prompts* and *probes Starter questions* provide a mechanism for starting the interview off in the desired direction. Second, *probes* must not affect the nature of the subsequent response, for example, 'Tell me a bit more about that' or 'Anything more?' (categorised as *reflective* and *request* probes). *Prompts* are short phrases which allow the interviewer to change the direction of the interview; 'directive prompts' to get the interview back on track and 'change of mode prompts', for example, from *what?* to *why?* and *how?* questions.

3.3.1.2 Focused discussion

This is closely akin to the question and answer strategy of the interview and introduces a focus into the interaction between the elicitor and the human knowledge source. It is primarily designed to elicit verbal reports rather than other behaviour such as physical activity. It is an introspective technique where the knowledge provider is asked to think about something of interest to the knowledge elicitor. The focused discussion can be distinguished from interviewing in that it introduces a third element, the focus, into the interaction between the elicitor and the human knowledge source. Killin (1987) identifies four associated introspective strategies:

- retrospective case description;
- critical incident strategy;
- forward incident scenario simulation;
- 'twenty questions'.

The focus for discussion can be many different items. According to Cordingley (1989), the focused discussion like the interview is a 'task-setting' and 'task-performance' interaction. The elicitor sets the knowledge provider a verbalisation task and the knowledge provider responds with a verbal report, possibly providing artefacts such as sketches, plans, diagrams or short written reports. The knowledge provider will want to perform the task well so it important to select an appropriate focus. Task-setting can be accomplished in various ways - a question, a statement or set of instructions. The knowledge to do the task must be accessible to the knowledge provider. Also, it is crucial that the elicitor makes it as clear as possible to the knowledge provider what is being requested. Lengthy preambles justifying the arrangement of the proceedings should be separated from the setting of the task. Otherwise, the knowledge providers may not be entirely clear about what it is they are expected to do.

There are a range of possible verbalisation tasks from which the elicitor can select when designing a 'focused discussion'. These include case-study tasks, where the knowledge provider focuses on particular cases. 'Forward scenario simulation' (Cordingley, 1989) is where the elicitor or the knowledge provider supplies an example situation or case and the knowledge provider describes, step by step, what would be done in the situation or when handling the case (Breuker & Weilinga, 1984). The cases chosen should either be real cases or simulate the type of cases the knowledge has been involved in previously. Shadbolt and Burton *(ibid.)* warn about the use of this technique with knowledge providers who find it difficult to verbalise knowledge. They recommend the selection of a rare or mundane case, both of which may be overlooked, in the cases knowledge providers may supply themselves without

direction from the elicitor. They believe that this can tap knowledge otherwise overlooked.

Shadbolt and Burton *(ibid.)* point out two problems with this technique. First, non-verbalisable knowledge (for example, pattern recognition) and second, compilation of knowledge, ie, knowledge that may have been learnt originally in propositional form and may have been sufficiently proceduralised so that experts regard the complex decisions that they make as based on intuition or hunches. Basically, the experts do not know how they carry out the particular activity.

3.3.1.3 Protocol analysis (PA)

This is a generic term for performing some sort of analysis of the expert carrying out a task, ie, solving a problem in the domain. In all cases, a record is taken of what the expert does, which may be written, or on audio-tape or video-tape. Protocols are made from these records and the elicitor tries to extract meaningful rules. Shadbolt and Burton *(ibid.)* distinguish two types of protocol analysis, namely, 'on-line' and 'off-line'. In on-line, the expert is being recorded solving a problem and at the same time a commentary is made. The nature of the commentary specifies the sub-type of this method. The expert may be explaining what they are doing as problem-solving proceeds (self-report) or another expert may do this.

Off-line PA allows the expert to comment retrospectively on the problem solving session - usually by being shown an audio-visual record of it. This can be done with the individual expert or several experts in group discussion. It is believed that different KE techniques can sort different kinds of knowledge. Protocol analysis is thought to specifically elicit the following types of knowledge:

- the when and how of using specific knowledge;
- problem solving and reasoning strategies;
- evaluation procedures and evaluation criteria used by the expert;
- procedural knowledge about how tasks and sub-tasks are decomposed.

For effective PA, Shadbolt and Burton *(ibid.)*, recommend that problems and data are presented in a realistic way as close as possible to a real situation. Protocol analysis, in a similar way to the unstructured interview, shares the drawback that it may deliver unstructured transcripts which are hard to analyse. One problem is that two actions which look exactly the same to the knowledge elicitor may arise from different considerations. A particular problem with 'self-report' is that it may interfere with performance. Context is often important to memory and thus to problem-solving abilities and this should be as 'naturalistic' as possible.

The above non-contrived techniques are natural and relatively easy to understand whilst the following techniques described below are contrived and allow the expression of knowledge in ways that are likely to be unfamiliar to the expert. In this research non-contrived techniques were used and a brief review of the following is included to cover the range of KE techniques.

3.3.1.4 Contrived techniques

Concept sorting

This useful when we wish to uncover the different ways an expert sees relationships between a fixed set of concepts. It is useful to explore the general interrelationships between concepts in the domain. The technique tries to make explicit the implicit structure that experts impose on their expertise. It is fast to apply and easy to analyse. It forces into an explicit format the constructs which underlie an expert's understanding.

Laddered grids

The expert and knowledge elicitor construct a graphical representation of the domain in terms of the relations between domain 'elements'. The result is a qualitative, two dimensional graph where nodes are connected by labelled arcs. Expert and elicitor construct the graph by negotiation and useful rules are derived from the graph. Shadbolt and Burton *(ibid.)* give an example of the use of this technique involving the diagnosis of VDU faults.

The limited information task

In the 'Limited information task' (Hoffman, 1987) or '20 questions' (Grover, 1983) the expert is provided with little or no information about a particular problem to be solved but must then ask the elicitor for specific information which will be needed to solve the problem. The information which is requested together with the order with which it is requested provides insight into the expert's problem solving strategy. The knowledge elicitor needs to be forearmed with a crib-sheet of answers to likely questions. In one version the expert is told that the elicitor has a particular scenario in mind and that the expert should ask questions to determine what it is. This technique may give information on the natural line of enquiry in a domain. Often expert systems gather and use the right information, but the order in which it is gathered and used can often be remote from the way a human expert works.

Automatic elicitation

As knowledge elicitation may be a difficult and time consuming process the idea of automated elicitation has led to the development of various computer programs. Shadbolt and Burton *(ibid.)* identify two types:

1. systems which implement standard KE techniques.
2. systems which use machine-learning techniques to induce rules from sets of worked examples and observed data.

Implementation of the 'repertory grid' (Kelly, 1955) has been the most successful of the type 1 programs noted above. This technique is designed to reveal a conceptual map of a domain in a similar fashion to the card sorting discussed above. Subjects are presented with a range of domain elements and asked to choose three such that two are similar and different from the third. The subject is then asked their reason for differentiating these elements and this dimension would be known as a 'construct'. The remaining domain elements are then rated on this construct. The process continues with different triads of elements until the expert can think of no further discriminating constructs. The result is a series of similarity ratings relating elements and constructs, which is analysed by a statistical technique known as cluster analysis. This technique can reveal clusters of concepts and elements which

the expert might not have articulated in an interview. The repertory grid technique is very time consuming to perform by-hand and the statistical analysis is complex and difficult to interpret. Thus a computer program to carry out this task is very useful.

Type 2 systems (above) are based on machine induction where a program is presented with many solved problems (or other suitable large data sets) from the domain and statistical analysis is used to infer underlying rules. Hart (1986) a reviews this technique and Shadbolt and Burton *(ibid.)* give an example involving the analysis of motor car 'symptoms' alongside decisions about fault diagnosis. It may be that the mechanic cannot articulate a rule relating a set of symptoms to a particular fault, but if they occur reliably with the fault, the program induces a rule. The next time this particular configuration of faults occurs then the appropriate diagnosis is made.

3.3.1.5 Classification of KE techniques

Shadbolt and Burton *(ibid.)* have attempted to classify knowledge elicitation techniques and this is given in the Figure below:

Figure 3.1 A taxonomy of KE techniques (Shadbolt and Burton, 1990)

NON-CONTRIVED
Interviews
- *Structured*
- *Focused discussion*
  - Retrospective case description
  - Critical incident strategy
  - Forward scenario simulation
  - Teach back
- *Unstructured*

Protocol analysis
- *Verbal*
  - On-line
  - Off-line
  - Shadowing
- *Behavioural*

CONTRIVED
Conceptual mapping
- *Sorting and rating*
- *Repertory grid*
- *Pathfinder*

Goal decomposition
- *Laddered grid*
- *Limited information task*

Automatic
- *Rule induction*

3.3.2 KNOWLEDGE ELICITATION METHODS USED IN THIS RESEARCH

The KE methods used in this research (outlined below in Chapter Four) were:

- the exploratory interview with the expert;
- the accompanied (observational) visit with the expert;
- the focused discussion with the expert;
- a newly developed knowledge elicitation technique involving videotaped information and a role-play simulation.

The latter method involved the provision of initial information using a short videotape. The participant (knowledge provider) had been set a task in the pre-consultation briefing and they were asked to give a concluding verbal report. In order to proceed with the task the participant had to obtain further information about the set scenario by questioning the interviewer. This technique has features of both a 'focused discussion' and a 'limited information task' in the above classification.

The method allowed a natural line of enquiry to develop in the dialogue between the interviewer and the knowledge provider. It proved to be useful in establishing differences/similarities in the approach to the task between different participants. A disadvantage with the method (common to most KE techniques) was that experts often found it hard to articulate their expertise and in this case if the expertise was not verbalised it is not captured for analysis. The advantages and disadvantages of this method are discussed in detail in Chapter Twelve.

4.

Methodology

4.1 INTRODUCTION

This research project is concerned with studying the expertise and approaches involved in hazardous substance risk assessment (HSRA) in order to make this knowledge more accessible to non-experts. The previous Chapter reviewed general aspects of expertise and the techniques, which have been used to elicit and structure human expert knowledge. This Chapter describes the methods used in this research where the objective was to study HSRA expertise from different viewpoints using a selection of KE techniques in order to develop a fuller picture of the skills and knowledge involved.

Chapter Two demonstrated that the occupational hygienist may be *the* professional specialist whose training most fits the requirements of HSRA. However, as has been already discussed, in practice other professionals often carry out this activity with some training in occupational hygiene principles. These professionals include, for example, occupational health nurses, occupational health physicians, health and safety practitioners, health and safety inspectors and also and general line managers. This work studies HSRA primarily from the point of view of the occupational hygienist, but in view of its importance the approach and differences of the other groups are also addressed.

4.2 KEY ELEMENTS OF HSRA KNOWLEDGE ELICITATION

These are listed below and were:

- the author's background training experience in occupational hygiene;
- a review of the literature of HSRA;
- exploratory interviews with experienced occupational hygienists;
- accompanying occupational hygienists on HSRA visits;
- focused discussions with an experienced occupational hygienist based on previous case studies;
- information and experience gained from training industrial line-managers in 'primary' HSRA;
- information and experience gained from the developing a HSRA aid for managers;
- studying the HSRA approach in different groups of health and safety specialists using the videotape KE method (pilot and main studies).

4.2.1 BACKGROUND EXPERIENCE OF AUTHOR

At this stage it is pertinent to describe the relevant background experience of the author in the light of the objectives of this research.

The author first qualified in Applied Biology specialising in Biochemistry and this was followed by a Postgraduate Certificate in Education and later a Master's degree in Occupational Safety and Hygiene. He has worked in several laboratories mainly in the field of Clinical Biochemistry and also as a Polytechnic Senior Lecturer in Occupational Health and Hygiene. This involved teaching on degree courses in Occupational Hygiene and Health and safety. In his current post he lectures on HSRA to the Aston University MSc/PgD course for HSE trainee inspectors and to other health and safety courses.

Furthermore, the author has had had extensive experience in practical occupational hygiene, particularly involving HSRA and carried out in a range of industries and types of organisation. He has arranged training courses on HSRA and other occupational hygiene topics in both the private and public sectors.

The author has been Chief Examiner in Occupational Health and Hygiene for the National Examination Board in Occupational Safety and Health (NEBOSH) Diploma examination since 1993.

This training and previous experience has significantly contributed to the author's ideas on modelling HSRA, which are developed later in this thesis.

4.2.2 REVIEW OF THE LITERATURE

The first objective was to collect key information on hazardous substance risk assessment as efficiently as possible. It was important to define terms, particularly the term: 'hazardous substance risk assessment' (HSRA) and 'hazardous substance'. These terms are broadly used in the same way as in the COSHH Regulations. However, COSHH does not apply to the flammable hazards of substances nor hazards from asphyxiant properties or solely as a result of temperature or pressure.

For the purposes of this research, it was decided at an early stage, that a 'hazardous substance' would not exclude these aspects of the hazardous nature of a substance, but in this work the primary concern is with toxic hazards.

HSRA is examined principally from the UK (and too some extent European) viewpoint and in this country considerable information has been published by the Health and Safety Commission/Executive in the form of guidance on the HSRA activity. As well as some more generic publications, much of this guidance has been tailored to the needs of different industry sectors.

4.2.3 EXPLORATORY INTERVIEWS

It was decided that personal interviews were an appropriate technique to begin studying experienced occupational hygienist exponents of HSRA. The objective was to collect information on general aspects of the activity and current practice from an occupational hygiene specialist's point of view. This was seen as a relatively quick and efficient means of achieving the objective. Exploratory interviews, together with other information gained from a review of the generic aspects of expertise, would, it was thought, allow development of ideas on methods for undertaking practical elicitation of HSRA knowledge. Interviews were arranged with experienced, working professional occupational hygienists.

These free-ranging interviews were concerned with hazardous substance risk assessment and management. The interviewer made a recording of each interview. Overall, the interviews provided much information about the strategy of different organisations in complying with the COSHH Regulations and the approach of the individual hygienists to practical HSRA. The contrasting approaches of the different organisations was of interest, as was similarly the role of each hygienist. The experience and viewpoint of individual occupational hygienists varies and of those interviewed, two were employed by large companies, whilst the other was employed by an enforcement authority.

Following the interviews full written transcripts were produced. Much of the discussions dealt with the strategy of the employing organisation (Hygienists A and B) in complying with the COSHH Regulations rather than the personal approach of the hygienists themselves to HSRA. However, with Hygienist C (the specialist inspector) some generic aspects of HSRA and more of his personal experience was highlighted. In these interviews some memorable case-studies were identified and examined. The interviews are discussed fully in Chapter Five and a sample interview transcript (for Hygienist C) is given in Appendix One (Section 14.1).

4.2.4 ACCOMPANYING HYGIENISTS ON RISK ASSESSMENT VISITS

The researcher has accompanied many occupational hygienists on HSRA consultations during his time working in health and safety. These were primarily advisory visits following a request, usually as a result of a concern or complaint about conditions by a visiting inspector, a manager or a member of the workforce.

However, on this occasion the objective was to observe the hygienists, themselves, as they carried out HSRA in a practical 'real' situation. Typical visits involved the occupational hygienist eliciting information about processes, people exposed and work practice. Hygienists were also interested in the manager's response to diagnosed problems, suggestions regarding proposed air contaminant monitoring and/or suggestions about feasible control measures. Occasionally, when practicable the interviewer asked the hygienist why they were asking a particular questions.

The visits produced much helpful information, it was noted that the hygienists demonstrated particular skills in eliciting technical information both from process experts and in discussing matters with both management and workforce. On several occasions further action such as air monitoring and additional control measures were recommended.

During one visit the researcher took detailed notes later producing a summary of proceedings (See Chapter Five). This visit is presented with an analysis using HSRA Model B (derived at a later stage in this research).

The key disadvantage of 'accompanied visits' as a method for a detailed study, was that it was not practicable to examine the same situation with different hygienists in order to compare their approach. It was not reasonable to ask managers and workers to cope with a series of people visiting a work area to ask the same or similar questions. Moreover, the manager's responses might well change between different participants as he or she (ie, the manager) learnt more about the subjects in question. Also, real workplace situations change and the object of study would in effect be different during each HSRA visit.

Therefore, a method was sought that would enable participants to be studied and their approaches compared. At this stage, the idea was first considered of using a videotaped case-study scenario. This had the crucial advantage that it was reproducible in terms of the initial information provided to the assessor and that it could be shown to different individuals under controlled conditions.

4.2.5 VIDEOTAPE KNOWLEDGE ELICITATION METHOD - PILOT STUDY

The objective was to study HSRA by looking for common features in the approaches of different hygienists when tackling the same workplace situation. Initial information was to be given to participants by videotape illustrating a workplace and production process. Further information could also be obtained from a surrogate factory manager, role-played by the author.

A suitable videotape sequence was selected by the author. The criteria used in the selection of the particular tape sequence were as follows:

- the tape was thought to provide an interesting, realistic and challenging simulated visit;
- the videotape sequence was taken by the author with the permission of factory management;
- conditions at the factory portrayed were thought to be typical of many small businesses using toxic and dangerous substances;
- the author had first-hand knowledge of the factory portrayed and the nature of its activities;
- the author had interviewed the factory manager, foreman and some of the shopfloor workers;
- the author had carried out personal monitoring of worker exposure to substances used at the factory;
- the author possessed manufacturers' hazard data sheets relating to substances used in the factory;

- the featured industrial process was not overly complicated for the experimental method envisaged;
- the tape was of a relatively short duration (6 minutes);
- the tape was realistic in that it featured some the key tasks of the process but not all (akin to a real survey visit);
- the tape content was very rich not only from the viewpoint of hazardous substance risk management but also from a general health and safety point of view;
- the (non-staged) tape represented a genuine, functioning small factory workplace.

The tape presents a short visual tour of the factory, its major manufacturing process and associated tasks. It was not comprehensive and not all relevant hazardous process tasks were illustrated on the tape. It was for participants to elicit such hazards verbally from the factory manager. Initially, participants were given standard written and oral briefings before watching the tape. This was to explain carefully what was required of them. Overall, the objective was to be as 'naturalistic' as possible within the obviously contrived aspects of the set-up. This was to make participants feel relaxed in order for them to perform the task as normally as possible.

A pilot study using this method was carried out and participants (occupational hygienists and trainee health and safety inspectors) were first briefed as to what was required from them. They watched the videotape through once (during which they were asked to make any relevant comments *aloud*) and afterwards they were asked to carry out a HSRA and give recommendations for action. The whole interaction was recorded on audio-tape in order to produce written transcripts for analysis.

Problems were encountered in structuring the analysis of the transcripts. The findings of this pilot study are discussed in Chapter Six and based upon these a wider and larger study, using this method, was proposed. This is discussed below.

4.2.6 FOCUSED DISCUSSION BASED UPON PREVIOUS CASE-STUDIES

The author had a series of focused discussions with an experienced occupational hygienist with the objective of analysing alternative approaches to HSRA. This person had experience of occupational hygiene consultancy, enforcement work as a specialist inspector and in academic research (primarily in hygiene standard-setting) and teaching. The author was well acquainted with this person and had worked with him in the early 1980s. (He was also Hygienist C in the exploratory interviews.) The technique used was to repeatedly discuss, and introspect on, memorable case-studies. This was to gain insight into the thought processes and knowledge used at different stages in a HSRA survey in order to write down or model this process. A generalised annotated model (HSRA Model A) was produced from these discussions and this is presented in Chapter Seven. This model focuses on the information required at major stages in the process, the general pathway and decisions the assessor has to make.

The members of a BOHS Technology sub-committee was asked for opinions and comments on this model (at an intermediate stage) and after discussions, some minor modifications were made. The model was based on an approach to risk assessment and control in a manufacturing production context. The model is discussed in Chapter Seven.

4.2.7 TRAINING INDUSTRIAL MANAGERS IN PRIMARY HAZARDOUS SUBSTANCE RISK ASSESSMENT

The author was involved in designing a risk assessment protocol and a training course, to enable industrial line-managers in a large manufacturing company carry out 'primary' HSRA. Although the company was a multi-national organisation with many production sites in the UK and overseas, to some extent central co-ordination of some common site activities had lessened. This included health and safety co-ordination and safety standards could be seen to vary widely around the different sites of the organisation.

The work involved structuring training courses and designing a risk assessment aid with complementary guidance to assist managers in this task.

The Company involved, had a strong central health and safety unit with site-based health and safety engineers.

The underlying basis of the strategy developed was that managers would carry out primary HSRA in their own departments and that *all* assessments would at some time be reviewed by a qualified health and safety specialist. Before training commenced the author had protracted discussions with the Company management and health and safety specialists, regarding:

- the management strategy for the whole programme;
- the detailed content of a primary assessment 'aid' (and guidance);
- the structure of the initial training course.

Initially a pilot factory site was selected in order to evaluate both the risk assessment proforma (aid) and success of the training course, before the were applied across the rest of the Company's principal UK factories. During the pilot stage, the risk assessment proforma and content of the training course were modified in the light of the manager's ideas and comments. Further, the performance of the newly trained managers in risk assessment was monitored by examining completed proformas. This was carried out by the author in conjunction with the pilot factory health and safety engineer, who was also a graduate chemist.

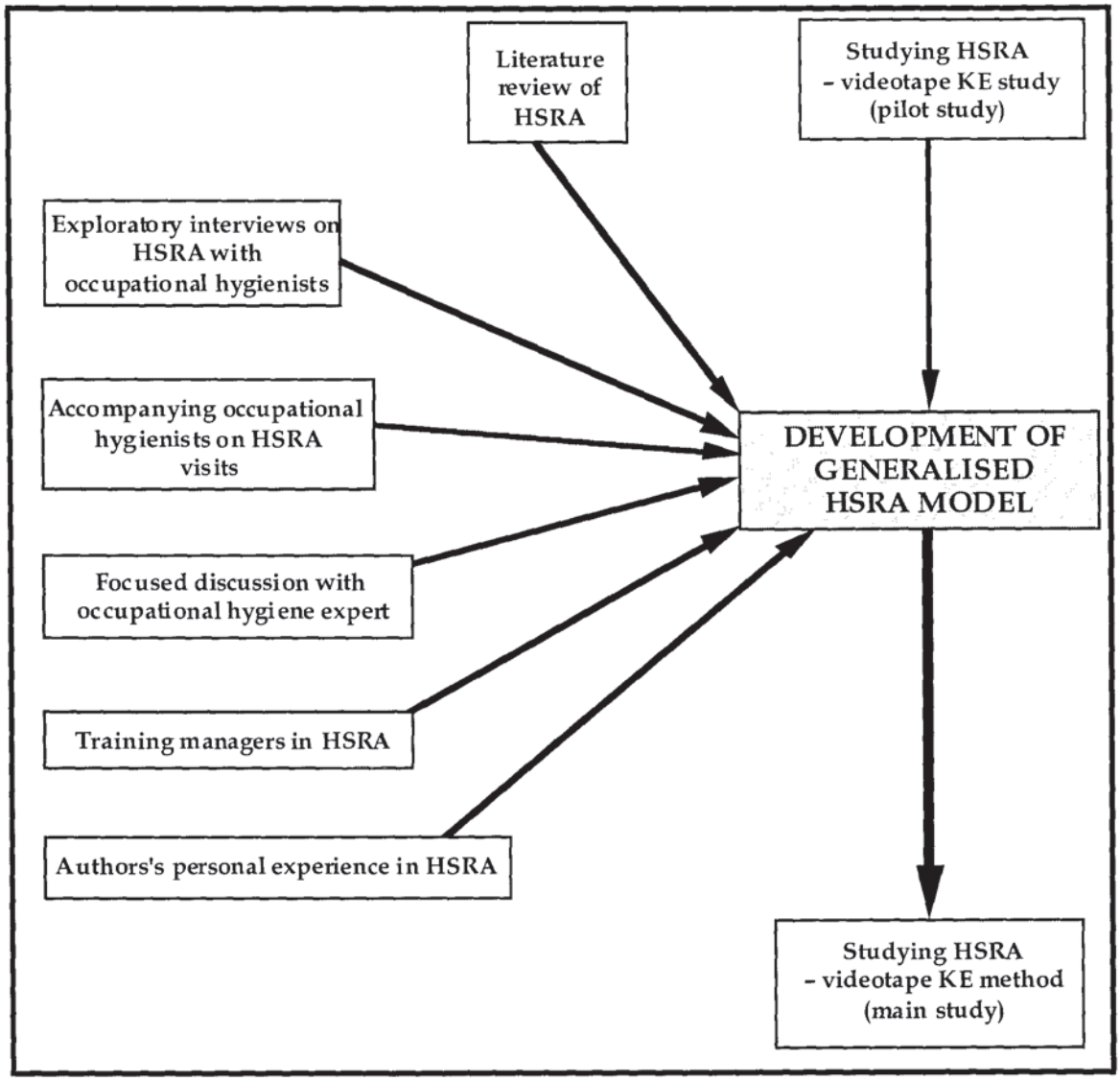
Eventually, around five hundred departmental managers were trained in the basic HSRA and use of the purpose-designed risk assessment proforma. The whole exercise yielded very useful data in highlighting the information and skills that managers needed in order to carry out primary HSRA in their own areas of responsibility. Further, it provided key information in how to produce a structured general pathway (in the form of a paper proforma) to guide them through this task. The nature of the training and proforma were very much adapted to cater for the needs of this particular company with its generally excellent provision of health and safety resources. These and other aspects are discussed in Chapter Eight, where a contrast is made with a similar exercise carried out for a small non-industrial organisation, which also needed to develop competence in HSRA, but under very different circumstances.

4.2.8 DEVELOPMENT OF HSRA MODEL

A model of HSRA was developed on the basis of previous sources of information (ie, the author's previous experience, the literature review, the exploratory interviews and visits with the hygienists, the focused discussions, the videotape KE method pilot study, experiences from the training managers).

This whole process is illustrated in Figure 4.1 and the model produced is discussed in Chapter Nine. This model was subsequently used in the interpretation of results of the wider videotape study discussed below.

Figure 4.1 Sources of information on HSRA



4.2.9 VIDEOTAPE KNOWLEDGE ELICITATION METHOD – MAIN STUDY

Following the conclusions and recommendations of the pilot study, it was decided to carry out a wider survey with some modification of the method. This was to overcome methodological shortcomings and problems with data analysis. The original briefing (Briefing One) was amended (Briefing Two) and participants were asked to watch the videotape twice and they were not requested to talk aloud during the initial showing of the tape. Another change was that during the second showing, participants were given the video-player remote control and they were able to navigate around the tape at will. Again,

this was to simulate some features of a real factory visit. In the main study, not only occupational hygienists and trainee inspectors were studied, but also groups of occupational physicians, occupational health nurses and health and safety practitioners.

4.2.9.1 Analysis of transcripts

Written transcripts from the main study consultations were analysed for content and approach to the set task. Following an extensive work, a classification and a matrix to evaluate performance in the exercise were developed. This followed several intermediate prototypes.

The classification was a series of categories (67) which were used to categorise text fragments from the consultation transcripts. The content of these categories was then analysed based on the generalised HSRA model B described in Chapter Nine. (Because of the quantities of data involved, this operation was only carried out for the hygienist group transcripts.)

An analytical matrix was also developed to allow evaluation of the performance of individuals participants and the specialist groups in the risk assessment exercise. An intermediate stage in the development of this matrix involved production of a comprehensive task analysis for the factory production process. However, this became too large and cumbersome to be of use. The final performance matrix has 137 categories in total.

The videotape KE study method is described in Chapter Ten and research findings are discussed in Chapter Eleven with methodological aspects are considered in Chapter Twelve.

5.

Knowledge elicitation – exploratory interviews and risk assessment visits

5.1 INTRODUCTION

Chapters One and Two demonstrate the discipline of occupational hygiene to be a key repository of knowledge and expertise in hazardous substance risk assessment and from the review in Chapter Three it can be seen that a variety of techniques have been employed to elicit expert knowledge. When commencing knowledge elicitation in the HSRA subject domain, exploratory interviews with experienced occupational hygienists and accompanying them on risk assessment visits was thought to be a useful and efficient initial approach to information gathering. [Author's note: The views expressed by the occupational hygienists in these interviews do not necessarily represent those of the author, nor possibly their own considered view when faced with a real situation.]

INTERVIEWS

The interviews were exploratory and the agenda was simply that the researcher was investigating the expertise of hazardous substance risk assessment and that the interview should focus this theme. All interviews took place at the convenience of the interviewee and at their place of work. The participants involved had extensive experience and were working in the following areas:

- industrial - employed by motor vehicle manufacturing company (Occupational Hygienist A);
- industrial - employed by a metals processing company (Occupational Hygienist B);
- industrial - employed electrical and engineering company (Occupational Hygienist C);

In some cases a follow-up interview was arranged to deal with any outstanding points of interest. Each session was recorded on audio-tape and written transcripts were produced.

The interviews were held in late 1990-1991, ie, not long after the introduction of the COSHH Regulations. They illustrate interesting and contrasting views on a range of topics concerning risk assessment at a time when organisations and the HSE were attempting to implement the Regulations (Both COSHH and the imminent MHSW Regulations). The comments, observations and opinions of these hygienists covered a wide range of subjects in the interviews including:

- the approach of organisations to implementing COSHH;
- methods of collecting of information;
- hazard identification and risk evaluation and opinions on air monitoring;
- risk tolerability;
- prevention and risk control measures;
- personal views on the activities of 'consultants'.

The interviews with the individual hygienists are each discussed in turn, with a commentary and there is a final overview at the end of this Chapter.

RISK ASSESSMENT VISITS

The author has accompanied occupational hygienists on risk assessment visits in the past, here the objective was to observe in detail the hygienist (rather than the workplace) carrying out a 'live' risk assessment in a genuine workplace. The visit involved a hygienist (employed by a large NHS Trust organisation) visiting the Pharmacy Department at their employer's premises. HSRA Model

B developed later in this research (Chapter Nine) is used retrospectively in the analysis of this visit.

5.2 INTERVIEWS

5.2.1 INTERVIEW WITH OCCUPATIONAL HYGIENIST A

This person had worked in the motor car industry for over 30 years. In a major part of the interview he described how his company had undertaken to comply with the 1988 COSHH Regulations and specifically with the "Assessment" requirements (Regulation 6).

5.2.1.1 Collection of information and hazard identification

Occupational Hygienist A summarised the bureaucratic process by which his company's chemical inventory was obtained. Operations encompassed eleven factories and 40,000 employees making the compilation (and maintenance) of an inventory a difficult logistical exercise. The inventory of substances in 1988 had 9,000 materials (individual substances and preparations) listed. However, by checking this list, the number had been reduced by about 1,500. For example, some substances approved for use by the company in the past, had now been discontinued or were no longer available. Hygienist A believed that his company had information on over 90% of products currently in use or available for use. Officially, an 'approved list' was in operation whereby a substance in use on-site must have health and safety clearance.

Having obtained the inventory, the next thing was to find hazard data on the materials. He explained that for some materials hazards were "self-evident", for example, substances such as acetone or sulphuric acid. On the other hand with some substances it may be necessary write to the supplier for information. He commented that he was not interested in the:

> ".... detailed formulation whereby this contains 14.9% of that and 17.2% of the other. We are just interested in getting a reasonable idea of the composition ..... You could not do it [risk assessment - author's note] without knowing what the composition is or what the most likely constituents are."

His opinion was that some suppliers of chemical products are very good and suitable information is given without much problem. However, other suppliers "vacillate":

> "When I get a reluctant supplier who will not supply me with the information, I get quite angry and I start writing letters."

When he has obtained a list of substances with information about their composition and the manufacturer's health and safety data sheets, he ought to be able to carry out a risk assessment:

> "First of all you have got to use your own knowledge, skill and training about hazardous substances. Nobody can store the knowledge of 1,000 substances, but you can get information from ....."

He related an incident where the manufacturer's hazard data sheet (HDS) did not fit in with his own company's experience of using a product. He cautioned that it was necessary to be vigilant and not accept hazard information without careful scrutiny. He cited an experience with one supplier who sent a data sheet claiming that their product generated a 'nuisance dust' (ie, produced very low or negligible effects on the respiratory system). Hygienist A had had personal experience that this was not the case and knew that this material produced an 'irritant' dust:

> "I can recall on a number of occasions where I would quarrel with that [the hazard data sheet - author's note]. My experience says otherwise. For example, we use a material called reconstituted polyurethane foam .....; we use a rotating tool that abrades or grates .... well it throws out little bits of chips and dust and they cling to your overalls by static, but also they get in your hair and everywhere, if you do not wear respiratory protection or have some extraction, your respiratory system is assaulted by this dust - it is relatively coarse in respirable terms but it is nevertheless an irritant - now the suppliers play it down saying it produces a 'nuisance' dust and it is not a hazardous dust - now I would not class it as a nuisance dust ..... it is primarily an irritant to the URT [upper respiratory tract - author's note] ..... your nose becomes very sore ..... whether it is the urea coated on the polyurethane foam I do not know - but it is certainly irritant to the respiratory tract not only mine but to every worker who uses it - so I would not describe it as a 'nuisance dust'."

The supplier had:

> ".... confirmed that it is a 'nuisance dust' in writing - as with all nuisance dust - by default."

By default meaning that in cases where no other information was available suppliers often use the term 'nuisance dust' to classify materials. This did not mean that Hygienist A did not believe in the concept of the 'nuisance dust':

> "Many substances do rate as nuisance dusts - the ACGIH still uses the term - they do not attack the respiratory architecture; the ones that they define are not irritant to the upper respiratory tract."

5.2.1.2 Risk assessment and COSHH

He outlined his company's strategy to cope with the demand for hazardous substance risk assessment:

> "Because we deal with many thousands of products, it is very difficult for us to write an individual assessment for every single product in every single way we would use it. The logistics of doing it are difficult - so we tend to use 'role models'."

He explained what was meant by 'role model.'

> "If you deal with a chlorinated hydrocarbon of a reasonable volatility it is the same as the next chlorinated hydrocarbon as far as the risk is concerned and as far as the control is concerned; I mean whether you use carbon tetrachloride[1], trichloroethylene or 111-trichloroethane (111-TCE) or dichloromethane would be neither here nor there if there was welding going on; in all cases those substances would break down to produce harmful substances and therefore you need to control and once you have made a decision about 111-TCE, it applies to the others the same - I know if you look in absolute terms - the toxicology of the one differs from the other - dichloromethane gets metabolised to produce CO in the blood whereas TCE does not nor does 111 TCE."

He explained how toxicological properties had been used to group substances into role models:

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[1] [Author's note: Carbon tetrachloride is considerably more toxic (hepatotoxin and carcinogen) than the other hydrocarbons listed and grouping them together in this way does not reflect this point. The assessment system developed by Hygienist A is to cope with 40,000 employees using 7,500 substances and preparations. However, it is important not to lose sight of important toxicological and other differences.]

> "We may class a substances a 'material producing an irritant dust on machining' - now other materials might be classified as 'materials producing irritant dusts as supplied' or 'nuisance dusts as supplied' or 'nuisance dusts on machining' or 'harmful dusts on machining'- now these are reasonable groups - they will stand on their own. You can say this substance is a material producing nuisance dust as supplied and there could be twenty other materials having the same properties - different makes and different compositions but the same properties - so you can produce a role model for that. So we are able to reduce the 8000 [in the inventory - author's note] down somewhat."

He gave a specific example:

> "If you have got a caustic alkali - once you have decided what the risks are and the way you are going to handle it, or spray it, dip it or whatever - you can define the necessary precautions, the necessary constraints or controls or first-aid actions; it does not matter if it is caustic soda, potash or a mixture of the two - a solution containing whatever percentage - until you get down to about 10% (a dilute caustic solution) you might decide that the risk is somewhat lower - and you would move into another role model. We have a number of role models."

He explains that there are 26 major groupings each defined as a 'role model':

> "The first two letters in our group number identifies the class - the mineral acids (01), the synthetic resins (02), the biocides etc. The next two (digits) are the sub-part of that group ie, 10 is highly concentrated; 11 - containing hydrofluoric acid; 20 - mineral acid dilute; so you would have the code 0120 this is a mineral acid and it is a dilute solution - 0110 it is a mineral acid at a high concentration - which of course begs the question of where does it change over - it is somewhere about 10%."

The role model system had developed over many years:

> "..... like topsy she grows - we could write the criteria down now - but I do not think we have done that in the past."

5.2.1.3 Risk evaluation

He explained how work processes and tasks were then incorporated into the risk assessment:

> "Now the code carries two more digits vitally important as far as COSHH is concerned because COSHH recognises that the process influences the risk."

> "At the moment we have identified fifteen or so distinct processes in our works; our ambit - 01 is always handling; if we have a flammable solvent we might want to mix it with paint to give the paint the right viscosity for spraying - we have got to handle it - it does not get out of the drum on its own - then having got our paint or solvent we may want to spray it - if we spray it - it will have a code 02 and every time you see the last two digits 02 it means spraying (not necessarily handled it may be directly fed from the drum!). If there is no risk then you have not got to do an assessment have you? We do not have to assess the handling hazard of something we are not going to handle!"

In answer to the question - 'What about where something is handled and sprayed?' He comments:

> "You need a separate assessment – one for handling and one for spraying. You would need separate assessments here because the risks would be expected to differ significantly with these two processes. It follows therefore that a substance could have more than one six-digit number ..... handling and spraying is a very common combination – there was one (product) this week with four or five (six-digit) numbers."

This meant that four or five separate risk assessments were carried out for this substance:

> "It was an interesting one it was a paint - the paint contained - chromate - when you handle the paint, really the risk is the solvent - so handling is one, but when you spray it there is a risk of inhalation of both solvent and chromate - then when the paint has been applied and stoved, it may be flatted down or abraded with abrasive paper which can generate a dust - and the dust can contain chromate - for example in the case of this paint which contained strontium chromate we were not particularly happy about its use without tight controls - for reasons which are known too well. So you can reflect, as I said before, by judicious numbering, the nuances of risk."

Because of the size of the company, the large numbers of employee, material and work-task combinations (ie, assessment situations) Hygienist A observed:

> "We are often doing assessments for processes we have not seen – I mean we may have seen the process elsewhere and of course if there is something very unusual about a process we will go and see it and I can think of one for a plant we no longer own, where, we sprayed molten solder - lead solder - pretty hairy and unusual - we went to look at the process before we made any decision about risk. Sometimes it turns out the we cannot make an assessment of likely exposure because we have not encountered this material before. So, we might have to go and measure it but by and large we can make an intelligent guess about what would be a likely exposure from our knowledge of processes - bear in mind we have had since 1961 to collect the experience and a lot people would not have that experience."

Once he had the six digit number (for a material and task) he would write the model risk assessment. He emphasised the importance of 'process experience' in this context. He believed this to be primarily based on experience in a particular industry. Furthermore, he thought that a crucial part of 'expertise' was to know the limits of one's knowledge:

> "I get phone calls sometimes from people who are doing consultancy in machine shops - never done a machine shop in their lives really - they are from the chemical industry - it is an alien environment; so they are going to miss the nuances because of a lack of experience not because of a lack of intelligence - they have enough intelligence to ask; the skill in this game is to know when you have run out of steam and have enough intelligence to ask. If we introduced an exotic chemical process which we had never done before we would have to go and enquire ....."

5.2.1.4 Tolerability of risk

Hygienist A explained his view of 'tolerable risk' (for inhalation exposure):

> "Our rule of thumb has been for a long time to try and design our controls for 50% of the occupational exposure limit [ie, the HSE enforcement limit – author's note] - I am a bit flexible about that, I might say 10% in some cases because I know it is a particularly nasty substance - as a broad brush approach 50%, if I can get people to work at about 50% it is do not ring me, I will ring you."

He did not rate very highly some published standards for inhalation exposure and commented that a few were particularly unsatisfactory, mentioning the limit for 'oil mist'. (In 1996, this standard was put under review by the HSC Advisory Committee on Toxic Substances.)

He gave examples of some of the criteria he uses in prioritising controls based on perceived level of risk:

> "Again you have to draw some line and it is a question of knowledge and experience – if you have got the knowledge a substance is question mark 'carcinogen' – or has very acute effects, short-term, - you have got to be a bit more cautious in what you aim for; if you have just got a URT irritant or nuisance or it has a smell or plenty of olfactory warning - you can afford to be more relaxed about it."

Air monitoring

For hygienist A workplace air monitoring was now a rare event. It crucially depended on how much previous knowledge he had of the process/task in question:

> "Because we have not encountered a material before, we might have to go and measure it [ie, the airborne exposure - author's note] but by and large we can make an intelligent guess about what would be a likely exposure from our knowledge of processes - bear in mind we have had since 1961 to collect the experience and a lot people would not have that experience."

Occupational Hygienist A did believe in *regular* air monitoring where this was appropriate:

> "My interpretation is that we should not be measuring something again and again. Only if it is necessary to maintain control. If I was working with TDI (Tolylene diisocyanate), for example, making polyurethane foams. Knowing what I know about this manufacture of foams based on five years experience of running a foam plant, I would do some measurements, and I would repeat them from time to time, but I would not just do blind measurements, I would do it as part of an audit - of the way we are running the process - human nature being what it is, people slip into bad habits over a period of time - they start off with all the protection on and when nothing has gone wrong nobody has dropped - nobody has died - you get a little bit further down the road - getting sloppy again - I think that is what health and safety is a about."

5.2.1.5 CONTROL MEASURES

Design stage

The company had a mechanism whereby new processes could be considered at the design stage and a predictive risk assessment carried out. Company policy was to apply engineering control wherever this was deemed appropriate and it was common to require local extraction ventilation (LEV) to be installed at this point in process development. Hygienist A commented:

> "In a substantial proportion of the cases we could make a decision from the data we have - or what we know about what is going to happen or the way it is going to be used, the plant – if, for example, you are introducing it in a low-roof building with pretty poor general ventilation - we might say have LEV anyway because of the difficulty - if it is a modern well ventilated plant we identify, good general workplace ventilation will suffice in many cases ..... occasionally we might say this is a bit unusual, it is out of our general level of experience we had better monitor, the material looks as though it is going to be particularly volatile and the way you are going to use it suggests to us that there might be a fairly heavy exposure or significant exposure we really ought to do some measurements – we almost take that as an admission of defeat."

Substitution

A spin-off from the role-model classification by generic groups was that it allowed substitute materials to be found from the overall database:

> "A simple example, the HSE have suggested recently [1990] we should not use sodium nitrite triethanolamine grinding coolants, because they produce nitrosamines *in vitro* and although the evidence is a bit tenuous about its carcinogenicity to man - it is quite clearly an animal carcinogen; someone the other day ..... introduced a very low-priced, very good buy sodium nitrite triethanolamine grinding coolant ..... we have a company policy we will not use this - Well what am I going to use? [says a production manager - author's note] - I cannot use anything other than this, the works are going to stop! Here is a list of twenty-seven coolants which do not contain amine and nitrite I am sure you will find one which will suit your purpose!"

Engineering control

Hygienist A observed that he was strongly in favour of engineering control where this was applied realistically:

> "I am a powerful advocate of LEV [Local exhaust ventilation - author's note] what I argue, lets say efficient as well as effective LEV, and efficiency has to take into account energy conservation. It is no good having an environment which is free of everything if the firm goes bust!"

However, regarding 'portable' ventilation extraction systems, he remains unconvinced:

> "People will not pull them around."

5.2.1.6 General comments

Integrated hazardous substance risk assessment

This interview was carried out before the enactment of the Management of Health and Safety at Work Regulations 1992, although Hygienist A commented:

> "Our COSHH assessments are intermingled with general assessment of hazard and risk including the fire aspects."

Occupational hygiene consultants

He has critical views on the operation of some occupational hygiene consultants:

> "They [OH consultants - author's note] are engendering the climate almost deliberately that you must have it measured etc. If I generate a concentration C at this point here on the bench, it does not require much knowledge to know that as we move away, a 100 metres away, there will be nothing, but you will have people doing processes here and metres and metres away doing sampling 'to check the spread' - what for?"

> "You get consultants saying that exposures should be less than 10% or less than 1% - they are not footing the bill to control it!"

5.2.1.7 Commentary

This interview provided a very lucid description of how a major company, with a small expert team, was coping with the logistical problems of carrying out risk assessment for the very wide range and numbers of hazardous substances and operations coming within its control.

The novel concept of 'role-models' had developed out of this company's many years of collecting hazard data – both from manufacturers/suppliers and from its own direct experience of the use of materials. Overall, this appeared to be a very powerful and efficient mechanism for carrying out basic risk assessment centrally, given the number of risk assessment situations (with 40,000 employees and around 7,500 substances and preparations). The crucial experience and skill appeared to be in developing the role-model groups assigning substances to appropriate categories together with categorising tasks (involving substances) into sixteen classes. The combination of role models and task groups was used to derive 'risk assessments', with the use of standard (legislative) risk phrases.

This interview highlights a novel and powerful mechanism for carrying out risk assessment from a central point. In some ways the company was I believe a victim of its own success in that this system tended to spoon-feed departmental managers with the answers for hazardous substance risk assessment. In 1992 the Management of Health and Safety at Work Regulations were introduced and there was no culture in the company of line managers carrying out risk assessment. This presented the company with some difficulties, which are still being resolved.

5.2.2 INTERVIEW WITH OCCUPATIONAL HYGIENIST B

This person was group occupational hygienist for a large metals and engineering company with over 20 years experience. As with the previous participant, in the discussion on risk assessment, this interview highlighted his company's approach to complying with the COSHH Regulations.

5.2.2.1 Collection of information and hazard identification

Occupational Hygienist B explained the background to their in-house COSHH assessment form, which had been designed by the medical department (primarily by the hygienists). This had been sent to managing directors within the company group and it was they who decided who was to carry out the risk assessments. The form was designed to be filled in by someone without a great deal of health and safety knowledge using hazard data sheets and other sources of information.

Within the company group who actually did the assessment varied. In a small company it could be the safety adviser, whilst in a large company the safety adviser may act as a co-ordinator and the task could be carried out by managers. (This contrasted significantly with the approach of Hygienist A's company above where all initial assessments were carried out centrally.) Referring to their assessment form, Hygienist B commented:

> "We designed it so that people could fill it in from their existing knowledge of the process; so it could be foremen with no experience of occupational hygiene or environmental work at all. They could fill the front part in, the second part they could get off health and safety or hazard data sheets and again with the knowledge of the process and the data sheet they could fill it in with ticks and crosses. And the next bit was existing knowledge, things like - is it already monitored? [air monitoring - author's note], again they ought to know that. From all that they ought to be able to decide whether they have got a problem or not. If they weren't sure we have left a facility there that they could say they weren't sure and come back and ask."

Rather surprisingly, the central occupational hygiene function did not examine the quality of these initial assessments:

> "We haven't seen the returns, we didn't expect any returns, they are kept in the factories."

The hygienists only become involved, it seemed, when a problem was flagged up. However, Hygienist B believed that the system had worked well as it was the intention of the occupational hygiene group:

> ".... not to do everything, well we couldn't do everything. The safety officer even, couldn't do everything. So it was down to the people at the sharp end who were actually using the stuff."

One surprise that was thrown up by the COSHH assessment exercise was the realisation that maintenance departments in particular tended to have many substances which they had not used for a long time, and which they were able to dispose of:

> "We just advise people that if they don't use it or haven't used it for two or three years then they don't need it. Get rid of it. And if you don't have it you don't need an assessment."
>
> It also made people in general much more aware of the hazards they were working with since they were having to read the hazard data sheets.

5.2.2.2 Risk evaluation

With a particular process the assessor decided on whether there was a risk:

> "If they couldn't come to the conclusion that there was 'no risk', then we looked at it or the safety officer in the factory looked at it and did something about it."

The company did encourage safety advisers to do basic air monitoring, for example, with stain tubes and this sometimes helped to flag up a problem. Hygienist B thinks the overall exercise has confirmed that the occupational hygiene effort, over many years, has been reasonably adequate because there were very few people with any problems. (He did not mention any specific training for the risk assessors, auditing or other checks on the assessments.) However, when asked about new substances, Hygienist B was less certain:

> "We wouldn't necessarily get to know about them unless *they* [the management or workers - author's note & emphasis] were worried, they would do an assessment using this form and the data sheets - you tend to get the same sort of new chemicals; its a very conservative industry; they tend to use things they have always used and they know that they don't react with the products or if we do use new materials then its using as a substitute kerosene or a petroleum-based cleaner instead of a chlorinated solvent."

Degreasing operations (involving chlorinated hydrocarbons) were a common process within the company. He had considerable experience at carrying out risk assessments on such plant[2]:

> "I think with things like degreasers there are the tell-tale signs like ironwork going rusty. Just looking at a tank and seeing the top coil is dry, or there is a slight whiff of Trike[3] as you walk when a chap drags the stuff out . I find normal trike degreasers, if its a proprietary installation like ICI designed, an installed tank then its usually operator abuse that is the biggest problem, drag-out - people don't notice that."

Some comments try to pinpoint features of risk assessment experience:

> "I think smoke tubes or that sort of thing are helpful but if there is a lot dust in the extract booth then it is obviously not catching the stuff. You know people can look at it and not see that. I'm surprised. Sometimes they want a number, everybody wants a number, they want know whether its 1m/sec or 1.5 not caring whether this just a slight inflow. Many times you could do the job with a Ventaxia fan or an Expelair if you stop the stuff escaping, but no, people have put a damn great 2 foot fan at 30,000 cfm and the operator hanging on for grim death when they are switched on because they are nearly sucking him through and they don't think and they don't look at the job before they design something. I think that's just experience. We've R, an engineering graduate, doing this job about 6-7 months and he doesn't see things even as an engineer."

This comment was explored with the aim of elucidating features of the expertise that Hygienist B thinks are underdeveloped in his new and inexperienced colleague. The author prompted him with a query about the sort of things his colleague missed:

> "Dust, even if there is dust all over the floor; fettling booth - the thing is so cluttered with tools that you are not going to get any air through ..... If you have got an extract system then it's not very much trouble to put in a little airline, have a little airline tube off the extract which gives you enough suck just to take the dust away if it does tend to build up. What they might do is to think, I have to put some more extract in there - it's not catching that dust from the process.

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[2] [Author's note: It is worth pointing out that in such situations, the provision of automatic, enclosed plant is always preferable where this is reasonably practicable.]

[3] Trichloroethylene - a common degreasing solvent.

Hygienist B highlights some indicators that would tell him that monitoring may be necessary:

> "If it was obvious that operators were genuinely affected, skin irritation or something like that, we would have to measure it with airborne monitoring or monitoring of some description. Even if it is looking at the oils and checking back with manufacturers.
>
> It's a difficult thing to say, I mean I am, again looking at it - looking how they work. You do not always have to, if a process is dusty and it is obviously dusty because the whole bench is dusty and everything behind them is dusty and the floor is dirty - then you do not need monitoring to tell you something needs doing and what I would rather do is look at the job and say well if you did it this way and you did it in a booth then you would be a lot better off because you can stop all that dust escaping. Then you don't need to know whether it's 10 mg per cubic meter to know that it needs controlling."

The management attitude to monitoring and quantitative information appears to vary within his company:

> "It depends who you are talking to within the company. I know people who will do things without monitoring and I know people who will not. But with the people who will not, it is because they need a figure to put on the capital expenditure report. If there is a large expense then they have a capital expenditure report and they have to justify it and they would be quite happy to believe there is a problem, but they have got to be able to break it down and justify it."

In agreement with Hygienist A, he explains that only in the case of isocyanates (and lead) is routine air monitoring carried out:

> "I do not think we really need anything else by regular monitoring. And again I would be quite happy to monitor isocyanates by just doing airflow measurements into the booth and making sure that the fans had been cleaned regularly."

5.2.2.3 Risk tolerability

Hygienist B outlines his view on tolerability of (inhalation) risk:

> "I take the view that when I explain to people that if someone is complaining about it, genuinely complaining about it – it doesn't matter what the level is, you have got a problem and if you have got a problem it could spill over on to something else. It could be that they need to walk out or in the extreme leave or refuse to cooperate in other measures that you want to do. So if you have got a problem and it is a genuine problem – well it doesn't matter whether it's above, below the OEL or any other. It is a problem! It will only go away if you do something about it. I think because I have been around long enough people believe me or they tend to."

And further:

> "We used to have a company policy that was an unwritten rule that you worked to half the old TLV [Threshold Limit Value] and that really has stuck. In the older factories who were in the system, they do work to half the TLV. Most places are quite conscientious if we are using things like isocyanates then they religiously monitor it, monitoring the workers if we are using lead. We had a lot of lead assessments in the early 80s when the Regs[4] came out, even down to quarterly (air) measurements in some foundries, which slowly tailed off as things came under control and now we perhaps monitor it not religiously every year, but on a basis, that we would do it when it was needed which is at least once per year. And we keep an eye on what blood leads are doing."

He commented on the highly unsatisfactory nature of some 'tolerable levels' used as enforcement limits, and again the case of 'oil mist was raised':

> "Things like oil mist - if you can see it coming off you do not need to monitor it. With oil mist in machine shops it is not likely to be over the OES anyway. Unless you cannot see across the other side of the shop. So if everything is oily and or if they are complaining of oil mist and you go in there and there is no sign on the control panels of the bar automachines or the guarding is dry then it's something that is local - need to have the toolsetting and things {rectified] - it is not a general problem. But if you go in there and everything is dripping, look at the roof and you get some oil in your eye then there is a problem. You are letting it escape - we have actually got a place where we have put some electrostatic precipitators one for two machines or even one to a machine to cure that sort of problem."

> "I think people do suffer discomfort - 5 mg per cubic meter of oil mist in air is absolutely horrendous [the current enforcement level - author's note]. You can ask any of our foremen in the machine shop what it used to be like before we put the 'smog-eaters' in. They came out of the office - they could tell whether they were on or not. Yet those levels were below the 5 mg per cubic metre standard and everybody was oily - I mean your skin your hair your clothes was actually soaking up the oil it was awful."

In this case he would nominally apply a standard of less than 20% of this OES standard value (ie, < 1 mg per cubic metre of contaminated air). Hygienist B outlined his personal criteria of tolerability for a job

> "My criteria really for occupational hygiene - would I do that job for 8 hours? And if I wouldn't then there was something wrong with it!"

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[4] Control of Lead at Work Regulations 1980

5.2.2.4 Control measures

Design stage

Unlike in Hygienist A's company, there is no formal mechanism by which the hygienists are consulted about proposed new processes at the design stage:

> "They [ie, trade union safety reps - author's note] are often more aware sometimes than designers, because they are the worst – the design people, production people as well. The designers, they get a good idea and put it on the drawing board and that's it."

In his experience this has ended up with:

> "Trike degreasers next to welders because everything that they weld is degreased and it is the logical place to put it so they can go swish and weld it. It's surprising how many times that happens. And they are all surprised when the welders refuse to work. The welders or the foreman picks it up rather than the people doing the lay-out."

Air monitoring

Hygienist B expresses a view on some consultants, commenting:

> "I think that you can do a lot of assessments without monitoring, I mean I get quite cross, one or two consultancies that go around and we will do your assessments but we've got to come and do all the air monitoring. I think that you don't need to monitor much. Even in the ICI film, the Millbank film it shows a safety officer waving the anemometer in front of the extract to see whether its efficient and the place is coated in dust all around on the floor on the top. You don't need an anemometer to tell you whether an extract is working or not working."

5.2.3 COMMENTARY

This interview took a different direction in comparison to Occupational Hygienist A. The company strategies were very different, since here there was little central control or seemingly involvement, in the risk assessments. A form was designed for the companies, but the assessors did not appear to have a programme of training and there appeared to be little systematic checking or auditing of the assessments produced and feedback on the usefulness of the form. The assumption seemed to be that if the assessments were filed then things must be satisfactory. This was based on the premise that the company had had hygienists working in the group for many years and it was perceived that most major problems had been identified and dealt with.

Hygienist B was an experienced occupational hygienist with considerable expertise in carrying out risk assessment on his company's processes as his comments on degreasing, dusty processes and the problem of oil mist indicate.

5.2.4 INTERVIEW WITH OCCUPATIONAL HYGIENIST C

Occupational Hygienist C had more than 15 years experience in academic occupational hygiene and consultancy. At the time of the interview he was working for a regulatory agency as a specialist occupational hygiene inspector. He commenced the interview by outlining his view of the first stages of generic hazardous substance risk assessment. This participant was principally concerned with carrying out HSRA on the premises of many different employers both large and small. (As a example, this interview transcript is included in Appendix 1.)

5.2.4.1 Collection of information and hazard identification

He commented:

> "I would find out about the processes that were used .... and I would now work from the rules of experience really. So I would say - Well, what quantities are involved? How many people are exposed? Whereabouts? How dusty? How hot? Do people come into intimate contact with it? Do they generate it by their own activities and therefore likely to be close to them or is it something given off in the room? Is it a large workroom? I suppose volatility - I would look it up if possible - it would give some idea if it is going to evaporate rapidly or not. I suppose more and more I would go on past experience. If its welding or rubber fume, whatever, I would go on past surveys. What other people found and what I found."

> "You look at the toxicity of the materials if that is relatively easily available, the principal products the company makes and principal components that go into the products. Hopefully therefore, the principal materials to which people are exposed. I would rank order it, trying to say well potential exposure to these substances and materials could be significant."

5.2.4.2 Risk evaluation

This comment illustrates the approach of the hygienist to HSRA:

> "So I suppose what I am doing all the time as a hygienist is looking at mechanisms of how the process works and how the process is causing exposure. If I have got some feel for how that is happening, I feel happier because I have got some connection between the process and the person's exposure, and that enables me to make sense of my exposure measurements and also to be able to control it. Until you have got that - you are stuck and you are swimming around in a sea of uncertainty."

Hygienist C is concerned with not only inhalation exposure, but also exposure by ingestion and skin absorption:

> "As a hygienist I tend to look at the process, the chemicals and the exposures - sometimes of course ingestion can be a significant route of exposure if not the principal one, and skin absorption. I would like personally to be able to have a good relationship with the occupational health nurse so that we could do biological monitoring together - so we get some idea of the dose absorbed."

> "And I am getting more and more interested in doing surface sampling - when it comes to particulates, to get some idea of the spread of the contaminant on surfaces in things like washing areas and washrooms, not because you can put any figure - limits on those numbers, but it just gives you some idea of the degree of spread of the material - we should then bring it to the attention of the management and workers that clean rooms are perhaps not as clean as they thought they were - clean areas in the workplace."

Hygienist C makes an observation on the usefulness of experience in predicting worker exposures and whether tolerability standards are exceeded. He also comments on the 'surprises':

> "Interestingly, when the (HMFI) chemical inspectors in the late 60s started doing measurements, they said that normally they could predict by looking at the process and naming the materials and so on, whether exposures were going to be excessive or not - when they actually did measurements they found usually that their hunches were correct. Sometimes they were caught out - sometimes they were much higher and sometimes they were much lower which bears out my experience."

As to situations where he had been 'surprised':

> ".... lead soldering survey - that was one of those examples where I was not sure what the results were going to be but I was surprised; but then when I went back and thought about it - there was no reason why I should have been surprised that the soldering iron's temperature was uncontrolled and I am not sure if we knew the temperature of the furnaces, but they were way above the vapourisation point of the lead; so in retrospect I could see why (exposures were high) and I suppose you could have said that would have been predictable if I had asked questions about the temperature of the irons - it is one of those things where one of those IR (infra-red) thermometers would have been very handy."

On another occasion:

> "I suppose I find that, however many surveys I go on I am always learning or reinforcing points that I have forgotten - I will never forget going to H Rubber Co coming to a large booth three metres (square) by about two metres in depth with just a single spigot at the back. Two thirds down there was a huge vortex within it, generated by the suction from the booth which meant that air was drawn in at the bottom circulated in the main body of the booth and poured out the top straight into the breathing zone of the person standing there. A really classic example of how you think drawing air out of the booth the air would go into the booth into the hole and out but it did not so it defies intuition again until you think about it and you realise what the mechanism is."

5.2.4.3 Air monitoring

Regarding this Hygienist C commented (similarly to Hygienists A and B, above):

> "Its more to do with experience really - I tend to monitor when I do not know the material and the process fairly well - isocyanates - it is not an area that I have dealt with that much, isocyanates, the role of the hygienist in many people's eyes is to measure and I do not necessarily think that is the case."

Sometimes a semi-quantitative measure such (as provided by a dust lamp) was often thought to be more useful than personal monitoring techniques, since with a visual method it was possible to see where a dust is leaking from and demonstrate to management and workforce that there is a problem:

> "There is nothing to beat a photograph and a dust lamp - a table of figures is very abstract."

However, measurements are often carried out when he is called into a workplace. This may have something to do with the fact that Hygienist C is only called in as a result of a general inspector's raised concerns:

> "So when would I do measurements? I tend to do them every time really; so that I am not caught out; so that if I think conditions are gross, I can clearly demonstrate if there is a legal limit and they are above it; - also because with some airborne contaminants you cannot see, taste or smell - normally you have to rely on instrumentation."

He acknowledges that small- and medium-sized enterprises (SMEs) are not in a position to do this type of monitoring, commenting:

> "What occupational hygiene needs is a 'memory' – a way of relatively easily accessing past exposures to similar processes."

> "You would want quite a bit of information about a process, the product, work method and the duration of the work during the day and the pattern over the week - putting all that together you probably say you know 90% probably not above or 100% certain you are not above the limit - or a certain number you do not have to use the limit you could use a fraction of the limit if you are a cautious employer. In a sense (I do not know what I feel about that) – That is a good way of saving you a good deal of effort and time and money."

Hygienist C is of the opinion that small organisations cannot afford excessive air contaminant monitoring exercises. He believes that it is pointless carrying this out repetitively for different small and medium sized enterprises (SMEs). In recent years several occupational exposure databases have been established to lessen the need for such repetitive monitoring in the case of similar processes, where this is possible (for example, Beaumont *et al.*, 1988). These are discussed briefly in Chapter Two.)

5.2.4.4 Risk tolerability

From his previous experiences of surveys Hygienist C remembers particularly his surprises with tolerability limits:

> "[At a paint factory] I was surprised how relatively low exposure to hexane was on one person we sampled working next to a mixer - given the amount he was splashing about and how he was handling it – I was amazed that he was not automatically over the hygiene standard."

> "I suppose that makes me think that generally or personally that exposure limits are *reasonably practicable* limits and I should not really be surprised when I see exposure relatively grossly out of control and yet they do not seem to be over the limit – 50% over it or whatever because the limit is extremely generous. So I should not be surprised – but I am and I, like everybody else, tend look at results in terms of above or below the limit or

> some percentage of it even if the limit is – well not meaningless but it stops gross uncontrolled exposure so I assume usually that is the case - not always though. Certain limits are so high that you have to work to get above them, the oil mist limit. It's clearly an out of date limit."[5]
>
> "I suppose rubber fume I have been surprised by many times – ten presses at Manchester and about 4 workers, all of them were over the limit some of them 2-3 times - and I was surprised. I thought they might be hovering about it or whatever. So it is sometimes difficult to predict."

He proposes two differing approaches to determining risk tolerability:

> "I do not think control of toxic risk is just about limits and measurements because I think that there is always a relationship between processes and levels of exposure and you could do as I describe and:
>
> "Look at the process and either say yes you are above or below the limit or look at the process and say while it is offensive or irritant material there is no limit for it let us just control it. (If anything you can say – are people still being offended by it? If no then you are OK)
>
> I personally think that is a perfectly valid way of dealing with what is a very uncertain topic – you know if we have 500 limits in this country and 50,000 chemicals in regular use."

Commenting on the regulatory approach to risk tolerability:

> "I think a major flaw in the direction in which HSE has gone – is to rely upon magic numbers of one kind or another. I mean large companies have difficulties in generating internal limits for their own use and small companies have not got a hope. So I think we are back into the good old days of Section 63 [Factories Act 1961 - author's note] and other similar regulations which say – if it is dusty you shall control it."

Furthermore:

> ".... limits is nice and easy (sic), a general exhortation to control dust or fumes whatever is not!"

However, this does not mean he is unaware of problems with this line of reasoning. Section 63 the Factories Act and other similar regulations:

> "do not say to what level – that is a problem - especially in a situation where the dust is an invisible respirable dust. I think sometimes that the

[5] This limit is currently review by the HSC Advisory Committee on Toxic Substances (1997)

> HMFI has been caught out – like with silica dust in foundries; I think just looking at it you cannot tell whether you are above or below the limit. With a dust lamp you can get more information – but you need to know the foundry industry quite well. Asbestos that is another one where the degree of dust control required to get to 0.5 fibres/ml is actually so severe you cannot make a judgement based on relatively crude 'just control the dust' type of commands."

5.2.4.5 Control

General aspects

Hygienist C then comments on what he believes are some of the problems faced by non-specialist general inspectors in assessing risk tolerability:

> "I think the problems that are probably occurring is – that one is a toxic one or this one has a limit and that sort of mesmerises them, so the fact that it has a limit and that it makes up 1% of the mix and it is not very volatile means that you can basically ignore, it but I think the trouble is people will home in on those substances that are listed in EH40 [HSE Guidance Note – author's note] or Sax[6] lists as toxic, and not relate it to the percentage in the material being handled, or the way it is handled. I think some people would do that and others would be more logical about it – we do not really handle it in a way in that it would be generating or released into the air."

Occupational hygiene

He expresses his particular interesting viewpoint on occupational hygiene:

> "You might find hygienists to differ in approach – I think it is such a giant subject, potentially, so that I feel quite comfortable in the biological aspects of it, and the engineering side of it I do not find that difficult – where I do feel I need to ask advice is in chemistry; that is the point about hygienists, it is a strange subject, it straddles a number of disciplines and the thing that the hygienist needs to learn today is – I have integrated a lot of different subjects and I do not need to know them all in depth.
>
> But if you are feeling insecure there is a tendency to go back to what you know, so if you are an engineer you go back to engineering, or chemistry, [...] that ultimately damages the subject because I do not think that occupational hygiene is biology or chemistry or engineering – it is a synthesis of all those together that's the power of occupational hygiene.

[6] Sax IN *Dangerous Properties of Industrial Materials* (A standard reference text)

> It is continually being eroded by lack of confidence within the profession but also by claims of other professions as well – the Factory Inspectorate regard occupational hygiene as just 'measurements', and it must be said that [UK] occupational hygiene developed within the Factory Inspectorate, and now specialist inspectors, their whole history is of measurement so they regard themselves as 'measurers' – self-perpetuating. I do not find that so much of a problem yet, but it may be ultimately."

5.2.5 COMMENTARY

Hygienist C takes a more detached view to the mechanics of HSRA. This is probably because he is involved in assessments in many different premises and the underlying principles rather than one company's strategy are more apparent. He proposes some challenging ideas on determining risk tolerability and control strategies. Interestingly, (and unprompted), isocyanates and the need for air monitoring and the inadequate standard for oil mist were both commented on, as did both Hygienists A and B.

5.2.6 OVERVIEW OF INTERVIEWS

In the two hygienists employed by the large organisations (ie, Hygienists A and B) the detailed organisational and technical approach to complying with the COSHH Regulations (particularly with respect to the assessment requirements) became a central focus. In contrast, the inspector hygienist took a more detached view of compliance and concentrated more on generic aspects of the HSRA task, since he did not discuss any single organisation in particular. Indeed he made some convincing comments about the needs and demands on SMEs in general with respect carrying out HSRA and complying with the COSHH Regulations.

The interviews provided considerable insight into the way occupational hygiene theory is applied in practice together with the views and opinions of those concerned on a wide range of issues (some controversial) such as the quality and accuracy of manufacturer's hazard data sheets, risk tolerability standards, the need for and frequency of air monitoring, the role of the consultant.

5.2.7 ACCOMPANYING AN OCCUPATIONAL HYGIENIST ON A RISK ASSESSMENT VISIT

The objective was to observe an occupational hygienist carrying out a risk assessment in a real workplace. The risk assessment studied involved a hygienist (employed by a large NHS Trust organisation) visiting the pharmacy department at their employer's premises.

The visit was a result of management concern about working conditions in the pharmacy department following a complaint by a member of the workforce. The researcher observed the consultation and took notes.

5.2.7.1 Pre-visit information

Initially the OH had little information about the risk assessment problem other than help had been requested, by telephone, regarding a process using IMS (industrial methylated spirit). The process in question was carried out on a small scale in the Pharmacy department, but much on a much larger scale in the Out-patients department.

There was a brief initial visit to the Pharmacy department for a meeting with a senior pharmacist (P_1). To maintain aseptic conditions and product protection in the area visited gowning-up was necessary. There was reported concern in the workforce about health effects arising from exposure to IMS and thus a risk assessment by the occupational health department had been requested.

Table 5-1 below presents a commentary of the visit which lasted 45 minutes. The following abbreviations are used: OH (Occupational hygienist); P_1 (Senior pharmacist); P_2 (Pharmacist); P_3 (Pharmacist).

Table 5-1 Analysis of accompanied HSRA visit

	Questions/observations	HSRA stage
	Initial general discussion between OH and P_1 about concern in workforce with the use of IMS in preparation of cytotoxic drugs; focusing on the nature of the substance and the necessity for aseptic conditions to protect product.	
OH	Booth? Is that a filter to reduce particles?	Evaluate and audit current controls
OH	Have you got a data sheet for this material?	Identifying typical hazard exposure
OH	So IMS is basically ethanol?	Task characterisation
OH	What is the volume of work?	Task characterisation
P_1	Most work using this occurs at the outpatients site with a small amount at the Pharmacy dept.	
	VISIT TO OUTPATIENTS DEPARTMENT:	
OH	How often and what happens on this process?	Process elicitation and task identification
OH	Can we see the job?	Process elicitation and task identification
OH	What ventilation have you got? There are lots of windows, a bit like a greenhouse.	Evaluation and audit of current controls
P_2	We have requested air-conditioning but this department is moving in one years time.	
OH	Have you any information on the 'cooling unit'?	Evaluation and audit of current controls
OH	The unit is intended to protect the worker from cytotoxic products?	Evaluation and audit of current controls
P_2	We are not sure what model it is! [No-one was quite sure where the air was coming from and there was a short inconclusive discussion.]	
OH	We are not sure about that air cooler? We need to check about it.	Evaluation and audit of current controls
	There was now visual observation as the task itself was demonstrated.	Task characterisation; hazard identification?
OH	(to P_2) Do you try to minimise use of IMS? How often do you top up container?	Evaluation and audit of current controls
	(P_2 – every 1-2 days)	Task characterisation
OH	Have you got PVC gloves?	Evaluation and audit of current controls
	(P_2 – We cannot use PVC with latex gauntlets.)	
OH	Can we establish if the gloves are suitable; the HDS mentions skin sensitisation?	Evaluation and audit of current controls
OH	The filters in glove box are not designed to filter IMS but only particles?	Evaluation and audit of current controls

Table 5-1 (cont'd)

	Questions/observations	HSRA stage
OH	How many units (syringes charged) are involved with the process?	Task characterisation
OH	Ready-filled syringes could lessen the load, but the demand for this process would still exist?	Evaluation and audit of current controls and task characterisation
OH	Eliminating a few products would therefore not be useful? (No)	Evaluation and audit of current controls
OH	Do you spray inside the cupboard?	Evaluation and audit of current controls
OH	How many containers of IMS are used?	Task characterisation; hazard identification
OH	Are the sprayers adjustable? (Yes)	Task characterisation; hazard identification
OH	How are they adjustable?	Task characterisation
OH	The sprayers are making a fine aerosol? (Yes)	Task characterisation; hazard identification
P_2	The smell varies from day to day; during cleaning twice per day there is a lot in the atmosphere.	Volunteers information
OH	The door is kept permanently closed? (Yes)	Evaluation and audit of current controls
OH	Who else does this job? (Two other people)	Hazard identification
P_2	We are concerned about health effects.	Volunteers information
OH	We will have to see how much of a problem exposure to IMS represents. We need to consider air monitoring and ventilation	Conclusion - recognised hazard but unsure about risk - further information needed
OH	How many hours per day is the process carried out?	Task characterisation and hazard identification
OH	75% of the time (5- 7.5h per day)	Hazard identification
OH	How many people are doing this job? (Two at the moment)	Hazard identification
OH	So it could be two people for 5 hours per day?	Hazard identification
OH	Could I speak to the other person?	
OH	(to P_3) What is your experience in there?	Hazard identification?
OH	How often are you here? (rotating every few months)	Hazard identification
OH	How many people altogether (10-12)	Hazard identification
P_3	Can IMS cause health problems?	Operator query
OH	I will go and have a look at the IMS, and consider what we need to do next. I accept nothing about that 'air cooler' device until I have checked it out definitively.	Conclusion - recognised hazard but unsure about risk - further information needed; examine control device
	END OF VISIT	

5.2.7.2 Commentary

Collection of data

The necessary data for the assessment was collected simultaneously for the different HSRA stages. For example, queries about the hazard data sheet, current control measures, health problems arising from exposure to IMS and the nature of the process activity arose at an early stage. There seemed to be no particular order in collection of data. The first question was about the nature of a control measure (clean enclosure). This equipment was visible on first entering the room before there was any detailed discussion of the process.

Conclusion on risk

There was an inhalation hazard posed by IMS vapour and the health risk from exposure to it may be significant. The reasons for this conclusion were as follows:

- two people carried out the task for most of the working day;
- work involved close contact with the emitting source;
- ventilation was judged to be poor; (there was 'cooler control' device, whose exact role is uncertain).

Recommendations and Action

These were to:

- check out cooler device;
- carry out personal monitoring (in-house) to measure IMS exposure.

Observation of this visit supported the view (elaborated on later in Chapters Nine and Eleven) that competent hygienists and others, when collecting the necessary data (illustrated in the various stages of the HSRA Model B), may not follow the sequence of stages in a logical order. In other words they collect information from various stages of the model at the same time. This allows them, efficiently, to elicit the process and identify tasks, identify hazards, evaluate current controls and come to a conclusion on risk.

5.2.7.3 Discussion

Much of the visit involved the OH eliciting information about process tasks, number of people exposed, work practice and the manager's response to diagnosed problems and suggestions regarding further action.

The visit produced much helpful information and the hygienist demonstrated skills in eliciting technical information both from process expert.

(In line with current practice, in the discussion of the interviews undertaken in this research, the term 'participant' will be used to denote the person interviewed).

6.

Knowledge elicitation – risk assessment case-study on videotape (pilot)

6.1 INTRODUCTION

This Chapter introduces a novel KE technique, which was examined in the following pilot study to decide whether a wider study would be desirable and feasible. An industrial scenario was presented to study participants using a short videotape and they were asked to carry out a health risk assessment at the factory portrayed. Any further information needed was to be obtained by questioning the surrogate 'factory manager' (role-played by the author).

The objectives of the pilot study were:

- to investigate the risk assessment approach of two groups of professional health and safety specialists;
- to evaluate the feasibility of the proposed method and to establish a practical protocol for future work.

6.1.1 VIDEOTAPE SCENARIO

The videotape scenario was introduced as a 'moulding process' and each person initially viewed the same tape sequence (approximately six minutes duration). This portrayed workers in a factory carrying out various tasks in a glass reinforced plastic (GRP) process for the production of specialised doors. The videotape had no commentary. Since the videotape is used extensively in

the subsequent main study, there is a detailed description of the factory and the videotaped sequence in Chapter Ten (page 205) and Appendix Six (page 378).

6.2 METHOD

6.2.1 SELECTION OF PARTICIPANTS

6.2.1.1 Occupational hygienists

Five locally-based (West Midlands) occupational hygienists agreed to participate in the pilot study. Each had a minimum of five years experience (by May 1992) in practical occupational hygiene and the group had a range of occupational hygiene and safety qualifications.

6.2.1.2 Trainee health and safety inspectors

Twelve volunteer participants were randomly selected from a group of students (Postgraduate Diploma in Occupational Health and Safety) studying at Aston University in 1992. This group had a range of academic backgrounds including both humanities and sciences. (All course entrants have at least first degree or equivalent qualifications). They each had at least one year working for the HSE as trainee general inspectors. Some had previous experience in industry and had been involved in implementing the COSHH regulations and one person had obtained degree-level qualifications in occupational hygiene before joining the HSE. Apart from this person, none of other participants in this group had any formal qualifications in occupational health and safety. (The students participated in the exercise *before* undertaking the occupational health module of the PgD course.)

6.2.2 EQUIPMENT USED AND DATA AVAILABLE

- Panasonic videotape player and television;
- Sony Dictaphone (Model TCM-38V) with remote microphone;
- Sony Handcam video 8 camera;
- simplified diagram of moulding process;
- lay-out plan of the factory;
- HDS (as supplied by resin manufacturer).

6.2.3 LOCATION

With two exceptions, the consultations with the occupational hygienists took place at their place of work. All other consultations took place at Aston University.

6.2.4 PROCEDURE

1. The structure of the consultations is outlined below in Figure 6.1. First, each participant was given a standard oral briefing on the objectives of the exercise. They were informed that the consultation was to be recorded on audio tape in order to obtain a full written record.

2. Each participant was asked to read a standard written briefing (Appendix 14.6, page 377, Version 2). Participants were requested to think *aloud* while viewing the tape. They were asked to carry out an assessment of risks from exposure to substances hazardous to health at the factory. The following instructions were given:

> "You will be shown a brief industrial case study on videotape. The primary purpose of the exercise is to assess risks to health from exposure to hazardous substances in the scenario presented. Describe the observations and questions which arise.
>
> After viewing the case study, when carrying out your review I would also like you to draw attention to other hazards you have observed together with other health and safety issues and the effectiveness of health and safety management at the particular premises."

1. Where further information was required, this was to be obtained by questioning the 'factory manager' (role-played by the author).

2. The videotape was then viewed and each participant commented aloud while watching the tape.

3. The participant carried out the risk assessment, as requested, asking questions to elicit further information about the factory and its processes.

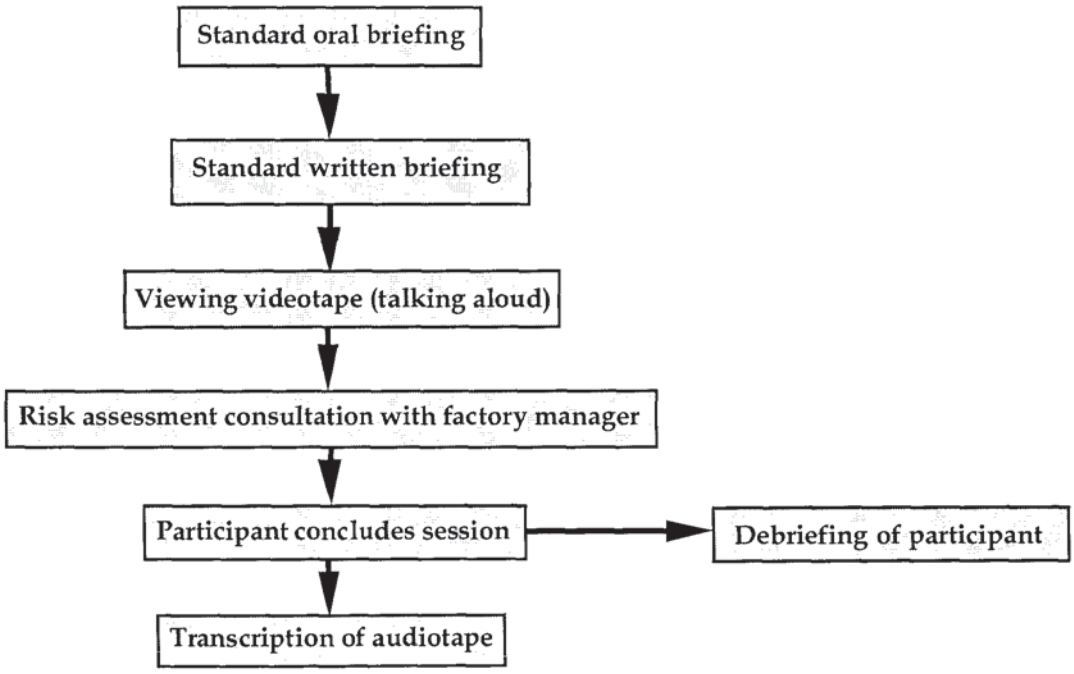
4. The consultation was terminated when the participant decided that he or she had enough information to conclude the risk assessment brief.

5. There was a short discussion and debriefing with the participant. They were asked to comment on the exercise itself.

6. A transcript of the consultation was produced for analysis.

7. The content of the transcripts was then analysed.

Figure 6.1 Pilot study procedure



6.3 RESULTS AND DISCUSSION

6.3.1 GENERAL

All consultations produced lengthy transcripts which illustrated various approaches to the risk assessment problem. Transcription was carried by the

author, and this took a considerable amount of time. Because of the different approaches of individuals, systematic analysis of transcripts proved difficult. Overall, participants concluded that there were exposures representing unacceptable health risks at the factory. Some participants assumed that there must be a significant risk simply because this process and videotape was being used in an experimental context.

Both occupational hygienists and trainee inspectors were highly motivated and completed the set task cheerfully within a reasonable time. Consultation times were all less than one hour and averaged around 40 minutes.

There was no significant difference in the mean length of consultations between the two specialist groups.

The request that the participants 'think aloud' during viewing the videotape did not produce useful information. It tended to be a full narrative commentary of what was in the screen at a particular moment - rather than yielding useful information any light on the development of a basis for risk assessment. Noise from the videotape (music from the factory radio) made it difficult to understand some comments.

To build up an overall picture of the transcripts, a total question count was made for each participant. 'Question count' in this context is a crude measure and crucially - what is a question? In the consultations, participants often implicitly asked questions by making apparent statements (where it may not have been possible to resolve the raised voice at the end - an indicator of a question). For example, 'There is no local exhaust ventilation' - as long as the manager believes the statement is correct, he does not need to respond. From simply watching the videotape a participant could not definitively know that this is true. Therefore, in effect the participant has asked a question but has used a statement as the vehicle. Such 'questions' have been counted in these estimates. The numbers of questions asked by participants are presented in Table 6-1 below.

Table 6-1 Ranked participant question count

Occupational hygienists	Question count
Participant 04	70
Participant 03	68
Participant 05	53
Participant 02	20
Participant 01	7
Average	44
Trainee inspectors	**Question count**
Participant 16	27
Participant 14	22
Participant 10	21
Participant 13	20
Participant 11	14
Participant 17	12
Participant 12	11
Participant 8	8
Participant 6	7
Participant 9	7
Participant 15	7
Average	14

6.3.2 OCCUPATIONAL HYGIENISTS

The average number of questions asked by the hygienists was 44 with a range of 7 to 70. With individuals asking the larger numbers, many questions were directed towards a systematic and detailed elicitation/understanding of the work process (Participants 3, 4, and 5). The initial objective appeared to be to obtain sufficient technical details of the process and the tasks involved in order to build up a picture of potential worker exposure to substances in use. For example Participant 3 asked:

"Can you describe the process from beginning to end?"

Participant 3 went into considerable detail to elucidate the nature and duration of the particular tasks and how they fitted into the overall process:

> "Roll and dab to remove air pockets between the mould and glass fibre - that will be part of the brushing process? Continuous - put on second layer brush with resin, roll and dab as before - does this harden or something then? So then we are repeating? - we do this twice then? It would take about two hours to do that would it? So they are just handling that (the glass fibre sheeting) for a few minutes at a time maybe 10 minutes?"

The following summed up the nature and purpose of Participant 3's line of questioning:

> "What am I trying to get at is what is given off when they are mixing the mould resin?, when they are using it? and when they are mixing the gel coating?, when they are brushing that on? - those are the processes of main concern - possibly that they could be a bit more careful with the glass fibre sheeting I am not so concerned about respiratory risks but the skin irritation maybe around the face and the neck that is the sort of problem I would anticipate - plus I would imagine that these things are quite irritating and I would probably recommend that they are a bit more careful prescribing protective clothing - yes because it is quite a dirty job - and then for that I would have a look at the data sheets - to see what their exposures are likely to be. So we have got styrene monomer given off? And you would have information available on the health risks of that? - occupational exposure standards? I would not know off hand - I am not worried about knowing specifically what the problem is, I know that it is a respiratory hazard – styrene and I would be concerned enough to do monitoring in this case."

Inhalation and skin contact exposure were primary considerations. In the experimental set-up, some hazardous stages of the process, for example, finishing, had to be identified from first principles since this activity was not featured in the videotape itself. The finishing task generated considerable quantities of airborne dust. Other commonly asked questions (not necessarily in this order) were to determine:

- any reported health effects in workers;
- the factory's hours of work;
- what substances were in use;
- if hazard data sheets from manufacturers/suppliers were available;
- there was specialisation in processes and tasks;
- current work practice and controls/personal protective equipment;
- the presence of other health and safety hazards.

There was a systematic build up of information with the primary objective to determine the potential inhalation exposure dose posed by the different tasks. Inhalation of styrene vapour and skin contact with the resin were concluded to be the major health risk exposures. Overall, these consultations contained many more questions than comments/observations.

Some hygienists (Participants 1 and 2) already had a generic knowledge of GRP moulding processes. When they initially identified the process, they were already aware that major exposures were likely to be styrene and inhalation of dust generated during finishing. They took short-cuts, since there were many aspects of the process which they took for granted and felt that they did not need to ask further questions about. One of these individuals did not mention any problem with skin contact and resins in the consultation. However, in discussion afterwards, he explained that he had been concentrating on the feasibility of controlling exposure to styrene vapour by engineering means, and that the absence of a comment about skin contact was a simple omission. This illustrates that knowledge allows experts to concentrate on narrower aspects, which may cause them to miss some of the wider view. The first comment in the consultation with Participant 1 illustrates his previous experience:

> "My general impression is that it is a typical sort of GRP (Glass Reinforced Plastic) fabrication and immediately I saw it I thought if it is GRP I would be really thinking about styrene exposure."

And at a very early stage in the consultation with Participant 2:

> "I would have thought they would have significant exposure to styrene; they would also have significant skin exposures."

These participants started from this premise about inhalation exposure and since they already had a very good picture of the technical details of the process, there few questions on these topics. These two consultations consisted more of comments and observations than questions together with detailed consideration of possible control measures. The focus of these consultations was on the feasibility of certain control measures.

On the whole the hygienists tended to be cautious in recommending controls - raising the possibility of ventilation engineering controls and details of other

protective measures, with their advantages and disadvantages. This contrasted with some of the trainee inspectors (discussed later) who had more crisp views on these matters. For example, Participant 9 stated without reservation at an early stage in the consultation:

> "I would definitely put an improvement notice on to get a ventilation system installed."

When discussing appropriate types of respiratory protection for the moulders, the hygienists on the whole went into more detail. For example, the possibility of airline-fed masks was raised, but with the proviso that their suitability depended on the required mobility of the workers in their work. There was a consensus that improved dilution ventilation, some type of respiratory protection and segregation of the moulds was needed during curing. On the feasibility of controls, Participant 3 (taking account of costs) comments:

> "From a look at the company they are not going to be able to afford anything high faluting!"

6.3.3 TRAINEE HEALTH AND SAFETY INSPECTORS

Previous training and experience

In terms of total numbers of questions asked, three of the four top scorers in this group (ie, those who asked most questions) had significant relevant experience in hazardous substance risk assessment (but not in GRP processing). Participant 16 had a degree in occupational hygiene and pollution; Participant 14 was a chemist with extensive laboratory management and COSHH assessment experience; Participant 13 was a chemist with experience in the paint industry and was responsible for carrying out COSHH assessments for a previous employer. Within this group these three individuals clearly had most experience of health risk assessment and therefore already knew many of the questions, which they needed to ask. If these three individuals were not counted in the trainees' group then the average number of questions asked by this group reduced to 11.

As noted earlier, when the consultations took place, the trainee inspectors had not taken the occupational health module of the Aston Diploma course,

although they had covered the basic elements of risk assessment. The occupational health module deals with the detailed aspects of HSRA and control.

During their first year with HSE it is a matter of chance what particular work individuals are assigned to. Time is usually spent visiting smaller factories and other premises. Participant 6 (an arts graduate) was by chance involved with the HSE Plastics Group, which resulted in her previously visiting several GRP-processing establishments. In the consultation this person asked relatively few questions, as did Participant 15, who had investigated a complaint about conditions in a GRP factory. Their low numbers of questions may have resulted from a belief they had enough background in general process details, so they did not need to ask many questions. However, another perhaps more convincing explanation may be that they were not familiar enough with the risk assessment task to know what information was required for this purpose. In contrast to the hygienists previously experienced with GRP processes, with these two individuals there was no detailed consideration of the technical aspects of potential controls.

Normal inspection role

Some trainee inspectors found it difficult to jettison their inspector's hat for that of the risk assessor, ie, the person charged with carrying out risk the assessment. In this exercise the participant is expected to play the risk assessor's role and for the inspectors this involves a change from their normal position. One participant (P17) persisted in discussing inspection and compliance techniques and acting out his normal enforcement role. The following question was addressed to the surrogate manager:

> "Do you think it is acceptable what you are doing here, the standards that you have got here?"

The manager role was intended to be an 'information provider' and not to take responsibility for the factory conditions. Although it was quite legitimate to seek information on the manager's attitude to health and safety in general, this participant, persisted with an accusatory line of questioning, even after several attempts at re-briefing. There are numerous instances in the consultations

where trainee inspectors have reverted to their normal inspection and inquisitorial role. Here, it seemed to be a deliberate ploy probably because of a perceived a lack of expertise in HSRA.

There was more heterogeneity in the approach of the trainees as would probably be expected from a group with such varied qualifications and experience. Commonly, they did not systematically extract sufficient information to build up a comprehensive picture of the process, and whilst some did focus on inhalation of styrene vapour as a problem, others did not make it a priority. Overall, consultations with the trainees had less direction than those with the hygienists, which clearly followed a sequence: hazard identification, risk assessment and control. With hygienists who had encountered GRP processes, these first two stages were condensed. The likelihood that styrene vapour exposure was unacceptable was in their minds early in the consultation and they quickly commenced examining the feasibility of control options. The trainees varied widely in considering the application of controls, although most made an attempt to go through the generic COSHH hierarchy. Overall, they were less certain about the feasibility of particular methods of control with some exceptions where opinions were more definite.

6.4 CONCLUSIONS

1. All participants, either explicitly or implicitly concluded that significant exposure to toxic substances, representing unacceptable health risks, were portrayed in the video case study. Some participants commented that they thought there must be a significant risk simply because of the use of the case study in this context.

2. On average, the occupational hygienists asked the factory manager more questions during the consultations than did the trainee inspectors.

3. Occupational hygienists with previous direct experience of GRP moulding processes asked fewer questions and made more comments/observations, than did occupational hygienists without such experience. At the beginning of the consultation, they identified exposure

to styrene vapour by inhalation as the major health risk problem. The laying-up task was identified as the major source of exposure.

5. Occupational hygienists without GRP experience commenced the risk assessment from first principles. They asked many questions to elicit process and task details and to identify hazards in order to evaluate the risks. Their approach to risk assessment was more transparent than that of the other hygienists.

6. Trainee inspectors with previous occupational hygiene and COSHH experience asked more questions than others in this group.

7. Unstructured consultation transcripts were difficult to analyse systematically and it is necessary to develop a structured matrix for this purpose. (The subsequent development of a transcript classification and a performance matrix are described in Chapter Ten.)

8. The overall collective view was that the following were noted as significant risks:

    - inhalation exposure to styrene vapour (principally from laying-up);
    - skin contact with resins during laying up and other tasks;
    - skin contact with glass fibre (GF) during laying-up and cutting GF sheet;
    - the possibility of noise and lighting was raised;
    - manual handling, fire and explosion, fork lift truck use.

Principal actions recommended by participants were (not in priority order):

- obtain hazard data sheets;
- carry out required risk assessments;
- segregation of curing;
- improve general ventilation;
- consider feasibility of local exhaust ventilation;

- provide personal protective equipment, respiratory protection, gloves, overalls;
- information, instruction and training for workers;
- monitoring exposure of workers to styrene vapour;
- basic health surveillance of the workforce;
- action on other health and safety risks.

9. The use of this method to investigate risk assessment expertise provided useful and interesting information on the approach of different individuals and specialist groups.

10. The protocol used should be modified for future work as specified below.

6.5 MODIFICATIONS IN CONSULTATION PROTOCOL

1. The structure of the consultation session needed modifications as follows:

- Participants should *not* be asked to talk aloud during viewing of the videotape.
- Participants should be encouraged to talk about what they are thinking during the consultation, since otherwise this information will not be captured on the audio-tape. This should be included in the written briefing.
- Each participant should view the videotape at least twice – once could be, in theory, an introduction to the factory and once more (at least) as a guided tour around the process. In the briefing the participants should be given the option of replaying the videotape more times if they think that is beneficial.
- Participants should be given the video player remote control so that they can replay, stop or fast forward the videotape asking questions at will.

- These changes were intended to make the session more akin to a real factory risk assessment, where the visitor has some influence on the direction of the consultation.

2. A clearer definition of the role of 'risk assessor' was needed so that participants know in what capacity they are at the factory. They should be asked to carry out a 'health risk assessment' and to 'recommend any necessary action'. The written briefing should state clearly that participants are not there as 'inspectors' nor have they any formal powers.

3. Examination of the transcripts highlighted some general differences in the approach of the occupational hygienists and the trainee inspectors. However, a structured matrix was needed to analyse the transcripts and evaluate performance of the participants systematically.

6.6 CONCLUDING REMARKS

The videotape knowledge elicitation method, with the above modifications was thought to offer considerable potential for studying HSRA and other applications, for example, training.

Much effort was subsequently was put into developing the means of structuring the analysis of transcripts mentioned above. Subsequently, the main study commenced with five groups of health and safety specialists (described in Chapters Ten, Eleven and Twelve).

7.

Focused discussion with an expert occupational hygienist

7.1 INTRODUCTION The aim of this thesis is to study how experts carry out HSRA and this Chapter describes a series of discussions with an experienced occupational hygienist (who was also Hygienist C in Chapter Five). This represents an additional technique for studying HSRA complementing the exploratory interviews and accompanied visits (Chapter Five) and the pilot study (Chapter Seven). The objective was to build up information by focusing on memorable HSRA case-studies and repeatedly recalling and discussing the steps involved. Case-studies involving exposure to Azodicarbonamide (as a dust) in a milling and bagging process, together with the styrene GRP process as well as other examples were discussed in detail.

The expert occupational hygienist, who participated, had a first degree in biological sciences, an MSc in Occupational Safety and Hygiene and a PhD dissertation on standard setting in occupational hygiene. This person had extensive experience in hygiene as a consultant, university lecturer and HSE specialist inspector.

7.2 METHOD

Memorable HSRA case-studies were identified and analysed in detail to elicit the approach of the hygienist. The examples were concerned with industrial manufacturing processes and both the participant expert and the author contributed their own case-studies to the discussions. At the end of each

meeting the participant and the author reviewed progress. During discussions notes were taken by the author to provide a permanent record.

A flow chart (Model A) was subsequently derived and this was submitted, for comment, to an expert group of hygienists (a sub-committee of the BOHS Technology Committee). Following a telephone conference of members of this committee to discuss the model (in December 1993) there were some (relatively minor) modifications.

7.3 RESULTS

Model A is presented below (Figure 7.1, 7-2 and 7-3) and this attempts to describe perceptions of the operational steps involved in HSRA and control. The major stages of HSRA which emerged from the discussions are listed and each of these will be discussed below:

1. Overview of production.
2. Coarse exposure assessment by workgroup.
3. Coarse ranking of processes/tasks for each workgroup.
4. Detailed exposure assessment – processes/tasks contributing to the exposure of each workgroup.
5. Ranking (by exposure potential) for the processes/tasks for each workgroup.
6. Grouping processes/tasks by priority for control.
7. Selecting the most appropriate blend of control options.
8. Apply, monitor and maintain controls.

The steps of HSRA and control are represented sequentially in the model, although it is believed that this diagrammatic logic does not adequately capture the actual situation in terms of the temporal stages of the process (as was the case with the risk assessment visit in Chapter Five and Model B). Often, risk assessors are thinking about exposure factors and possible control

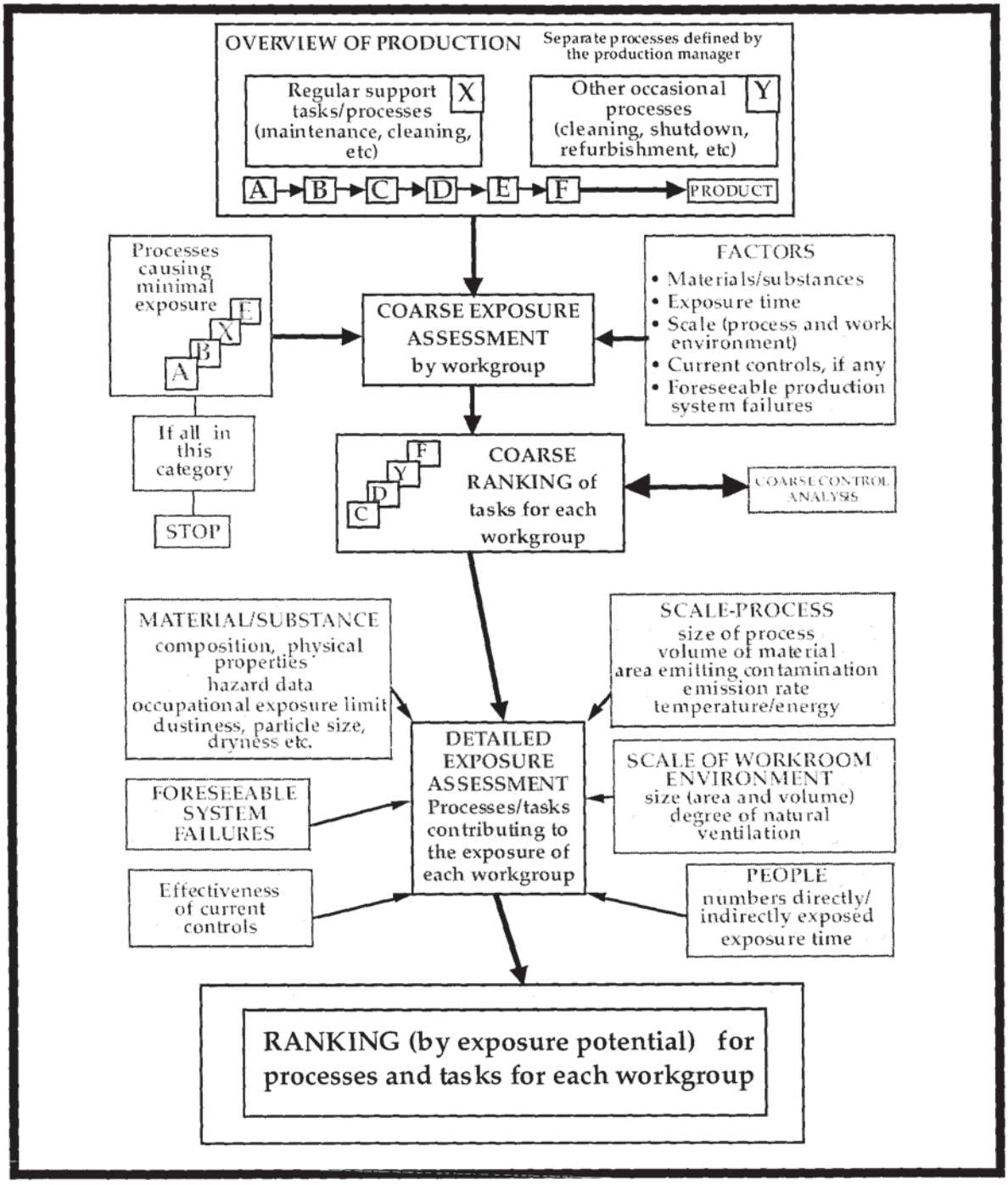
measures at the same point in time. The model represents the necessary stages to capture relevant key factors to exposure assessment and control applications. However, the order of collection is probably much more opportunistic, in that assessors try and collect what information they perceive they need as efficiently as possible.

First, the assessor visits a workplace and asks the manager (or in the case of a new process – the designer) 'What are you making?' and 'What is the process by which you make it?' 'Can we just run through the process stages?' There is also a need to consider *occasional* processes, which may be very important from an exposure point of view, such as maintenance, plant shutdown and cleaning.

With this in the mind's eye the assessor runs through a coarse exposure assessment, looks at each process and significant tasks in each process, taking into account various factors such as material, people exposed, scale, current controls. There is a focus on those processes/tasks, which look as though they contribute significantly to exposure. Where there are significant exposure-generating processes/tasks, then there is a detailed exposure assessment looking at the range of factors listed. Each factor is considered in turn.

Finally, there is a ranking of processes/tasks for potential contribution to exposure and this should indicate where most exposure control is needed for the workgroup in question. The final part of the model (Figure 7.2 and Figure 7.3) is concerned with controlling exposure and considers the factors for achieving an optimum *blend* of effective control measures.

Figure 7.1 Model A (Exposure evaluation)



7.3.1 OVERVIEW OF PRODUCTION

Initially, the assessor needs an understanding of production which includes the usual steps in production, regular support tasks (such as maintenance and cleaning) and the other occasional processes such as refurbishment after shutdown. This involves asking many questions in order to fully identify and understand the basics of the manufacturing pathway. Basically, all the

production stages need to be elicited from raw materials to the finished product.

7.3.2 COARSE EXPOSURE ASSESSMENT BY WORKGROUP

Workgroups have to be determined for the production process. (This is a group of workers who have the similar exposures to hazardous substances.) It allows the identification of task specialists who may have more intense exposures. This stage is to separate and dispense with production processes which result in minimal or insignificant exposure. There is then an assessment of the potential of each stage of production (denoted as separate 'tasks') within a process for its potential to cause exposure. The factors to consider are listed and include:

- identifying materials/substances;
- composition of materials/substances
- exposure times;
- the scale of the process and work environment;
- current control measures and their effectiveness;
- foreseeable production system failures.

7.3.3 COARSE RANKING OF PROCESSES/TASKS (FOR POTENTIAL EXPOSURE) FOR EACH WORKGROUP

If all tasks come within the 'processes causing minimal exposure category' then exposure assessment stops. The assessor has decided that there is no likelihood of significant exposure. Assuming this does not occur the assessor produces a coarse ranking of tasks by potential contribution to exposure.

7.3.4 DETAILED EXPOSURE ASSESSMENT

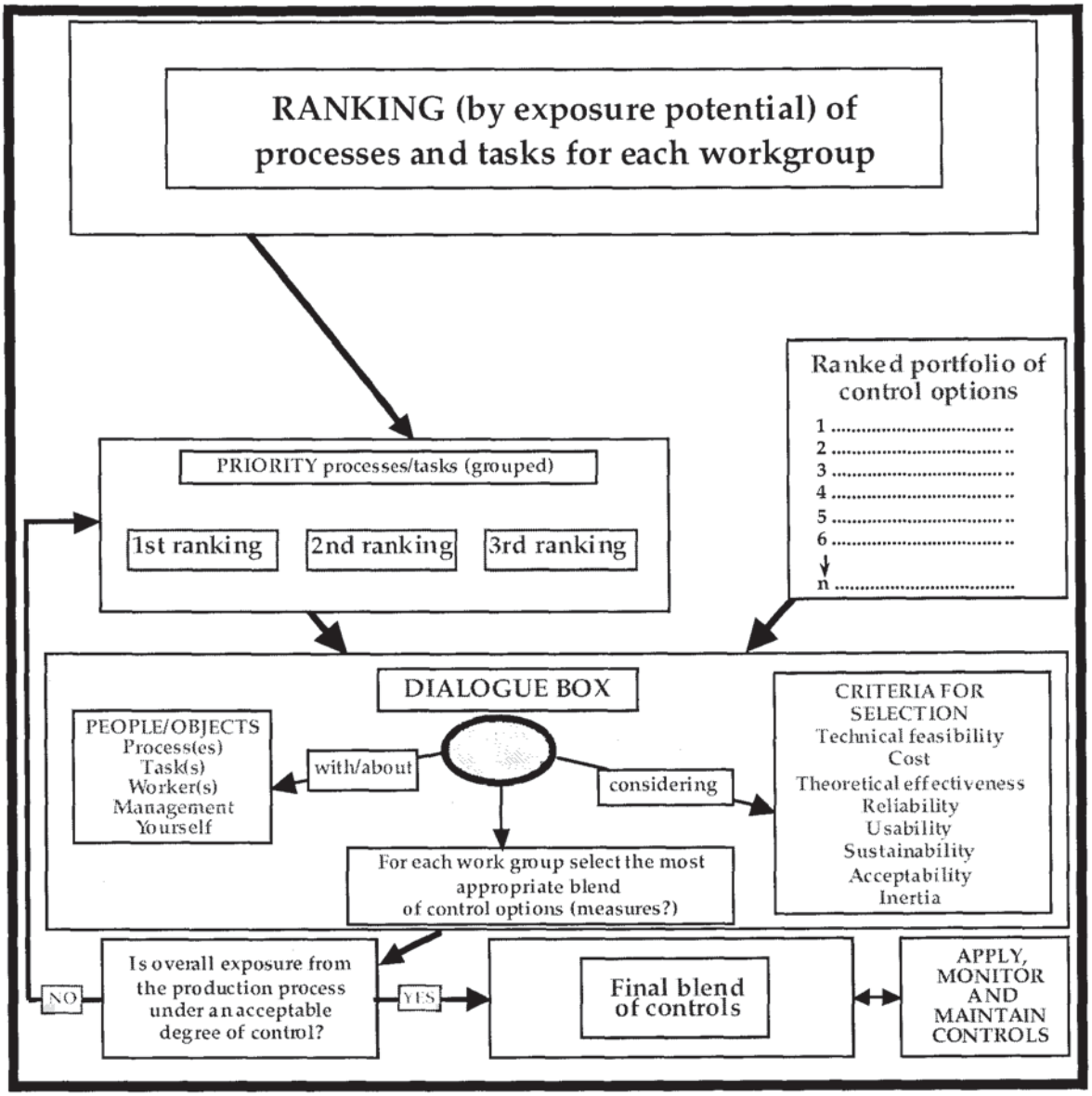
Each of the processes/tasks identified in the coarse exposure assessment is examined in more detail at this stage. An attempt has been made to list

appropriate factors which the assessor may need to consider. Where the assessor has relevant process experience, a ranking of tasks in terms of risks arising can be done without quantified measurements but often air sampling will be needed to confirm intuitive feelings. A detailed examination of the processes and tasks which contribute to the exposure of each workgroup is undertaken and factors include:

- the scale of the process;
- the scale of the workroom environment;
- people exposed;
- materials and substances used;
- the effectiveness of current controls;
- foreseeable system failures.

Each are each considered in turn. By the end of the detailed exposure assessment the assessor has ranked processes and tasks by relative contribution to the time-weighted average (TWA) exposure of each workgroup. Processes and tasks are then grouped by priority for control.

Figure 7.2 Model A (Control)



7.3.5 CONTROLLING EXPOSURE

The chart attempts to describe the steps used by the assessor when seeking the most effective and efficient selection of control measures starting with the tasks causing the most exposure.

7.3.5.1 The 'Dialogue Box' and selecting the most appropriate blend of control options

The most appropriate blend of control options is selected for each workgroup. If it is considered that overall exposure is now under acceptable control (ie, tolerable levels of risk) then the final blend of controls is applied, monitored

and maintained. This is a complicated process involving considering of a range of factors. A ranked portfolio of control options is available – for example, elimination of a hazard, local exhaust ventilation, personal protective equipment and other measures. A deliberate attempt was made to avoid the term 'control hierarchy' because it became clear the aim is an optimum blend of controls. The end result is a set of controls which will work and will be maintained. Control measures are applied until it is decided that the overall exposure is under an acceptable degree of control.

The assessment according to the findings of our discussion will look at each task and select the most appropriate blend of control options bearing in mind their ranking within the control portfolio. An attempt has been made to list the selection criteria which will be considered and the people and objects with whom the assessor will have a 'dialogue'. It was concluded that a variety of factors are taken account of when these decisions are made.

By the end of the dialogue process, which may need to consider the second and third ranked tasks, one ends up with a final blend of controls. It is then a matter of applying, maintaining and monitoring the instituted control measures.

There are a range of criteria for selection to be considered:

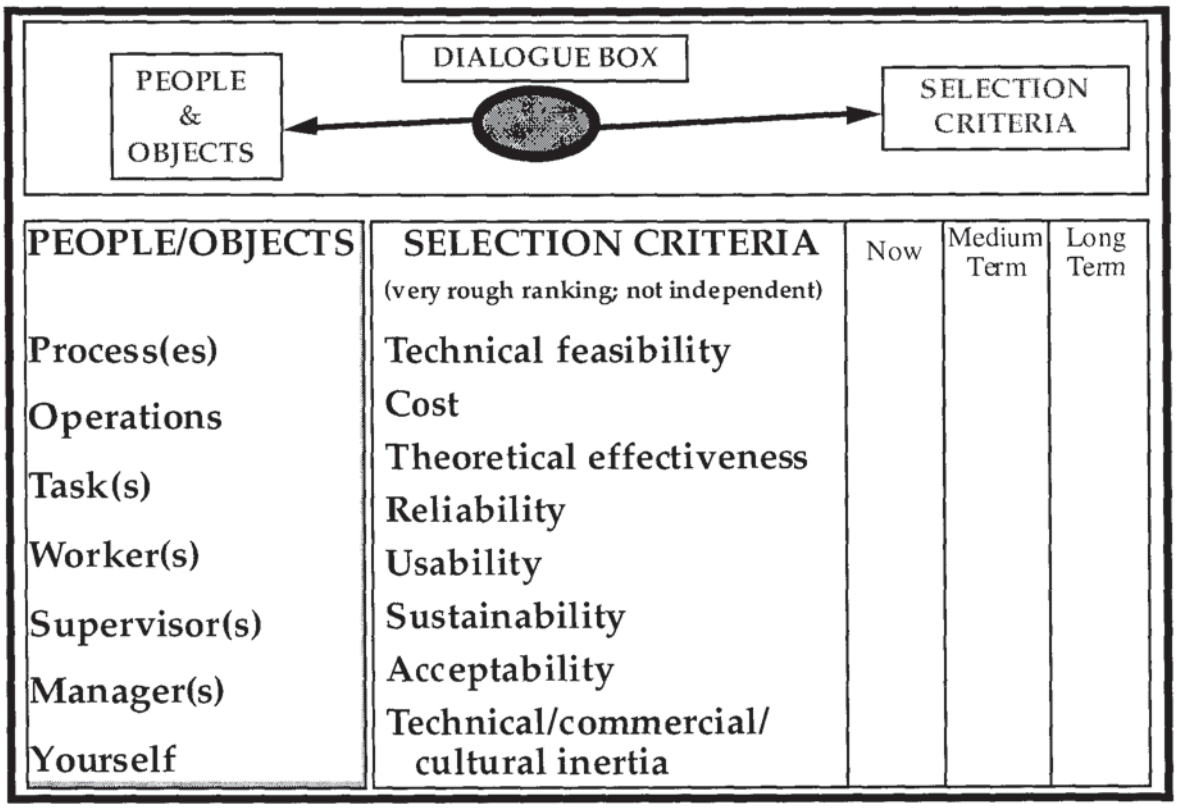
- cost;
- theoretical effectiveness;
- reliability;
- usability;
- sustainability;
- acceptability;
- commercial, technical, cultural inertia.

Furthermore, these should be considered not only in the present-day context, but also taking into account possible or predictable medium and long-term developments.

7.3.6 APPLY, MONITOR AND MAINTAIN CONTROLS

Once the optimum blend of controls has been chosen, then these need to be applied, monitored and maintained.

Figure 7.3 Model A (Control factors)



PEOPLE/OBJECTS	SELECTION CRITERIA (very rough ranking; not independent)	Now	Medium Term	Long Term
Process(es)	Technical feasibility			
Operations	Cost			
Task(s)	Theoretical effectiveness			
Worker(s)	Reliability			
Supervisor(s)	Usability			
Manager(s)	Sustainability			
Yourself	Acceptability			
	Technical/commercial/ cultural inertia			

7.3.7 COMMENTARY

The assessment and control determination process has been kept as simple as possible without sacrificing key elements of the model. The aim is to make transparent the factors, criteria and actions which a hygienist needs to take account of or do to identify significant sources of over-exposure. Consideration of the above allows determination of optimum control measures for each workgroup. The chart will be best understood when applied to a practical example.

7.4 CONCLUSIONS

1. Model A aided this study by clarifying the mode of operation of the expert and this information contributed to the derivation of Model B later (Chapter

Nine). Model B was applied in analysis of the videotape case-study exercise presented in Chapters Ten, Eleven and Twelve.

2. The discussions suggested that a task-driven risk assessment approach appropriate in most situations.

3. The discussions produced a general framework linking stages of the risk assessment and control task. As discussed above, the temporal sequence of HSRA steps and factors is believed to be very complicated. This diagram does not display this complexity, although it is useful to highlight key stages in the process.

4. In its 'Dialogue Box', Model A has made explicit the factors used for selecting appropriate and effective control measures.

8.

Hazardous Substance Risk Assessment training and aid

8.1 INTRODUCTION

This Chapter describes the development and application of a risk assessment aid complemented by bespoke training to assist a large multi-site manufacturing company in carrying out HSRA. The aim of this training was so that managers could carry out primary HSRA in their own areas of responsibility. The work provided insight into the needs of line-managers who were familiar with the processes and tasks, but not with the other aspects of risk assessment. Finding out how experts carry out HSRA is a vital aspect of this thesis, but it is also very important to elicit the needs of 'non-experts', in this case managers.

The development of suitable training and production of a helpful proforma utilised much of the information elicited from the occupational hygienists as described in Chapters Five, Six and Seven of this thesis. This experience and information gathered from this work itself, contributed to the derivation of Model B described in Chapter Nine.

Since their introduction in 1989, many organisations have had problems with the implementation of the COSHH regulations. This has occurred not only in small and medium-sized enterprises (SMEs) as might have been expected, but also in larger organisations. The author has assisted various organisations to comply with the COSHH Regulations. This has mainly involved SMEs who did not employ health and safety specialists. The primary concern was

compliance with the risk assessment requirements embodied in Regulation 6 of COSHH.

Although the legal duty is the same irrespective of the size of an organisation, it is obvious that the strategy for a large multi-national organisation will be very different from that of a small company. Risk assessment guidance was required in very various forms. The development of HSRA aids for two very different organisations - namely a large multi-site company and a small social club (Organisations X and Y respectively) are contrasted in this Chapter.

8.2 ORGANISATION X

This was a large multi-site industrial engineering organisation. Extensive decentralisation and downsizing in the 1980s led to a loss of central co-ordination of some key functions, including health and safety. In effect, in certain aspects, the organisation functioned as a collection of SMEs. Following an incident (and consequent enforcement action) with toxic substances at a factory site belonging to the company, the author was asked to develop a strategy for HSRA (and compliance with COSHH) across the whole organisation, since at this time there appeared to be a lack of direction and support for toxic substance management. A structured risk assessment aid and training package was developed as part of an overall strategy to rectify this situation.

The initial toxic substances problem occurred at a factory site where there was a misunderstanding caused by lack of training, and a misunderstanding with the company's previous assessment form. This resulted in confusion in what was needed to comply with COSHH and how to carry out risk assessment.

8.2.1 TRAINING STRATEGY

Following discussions with company management and senior health and safety personnel, departmental managers were identified as the key individuals to carry out 'primary HSRA'. These individuals had important knowledge of processes and task specifications and current work practice. This primary risk assessment was to be carried out within a 'supportive framework'

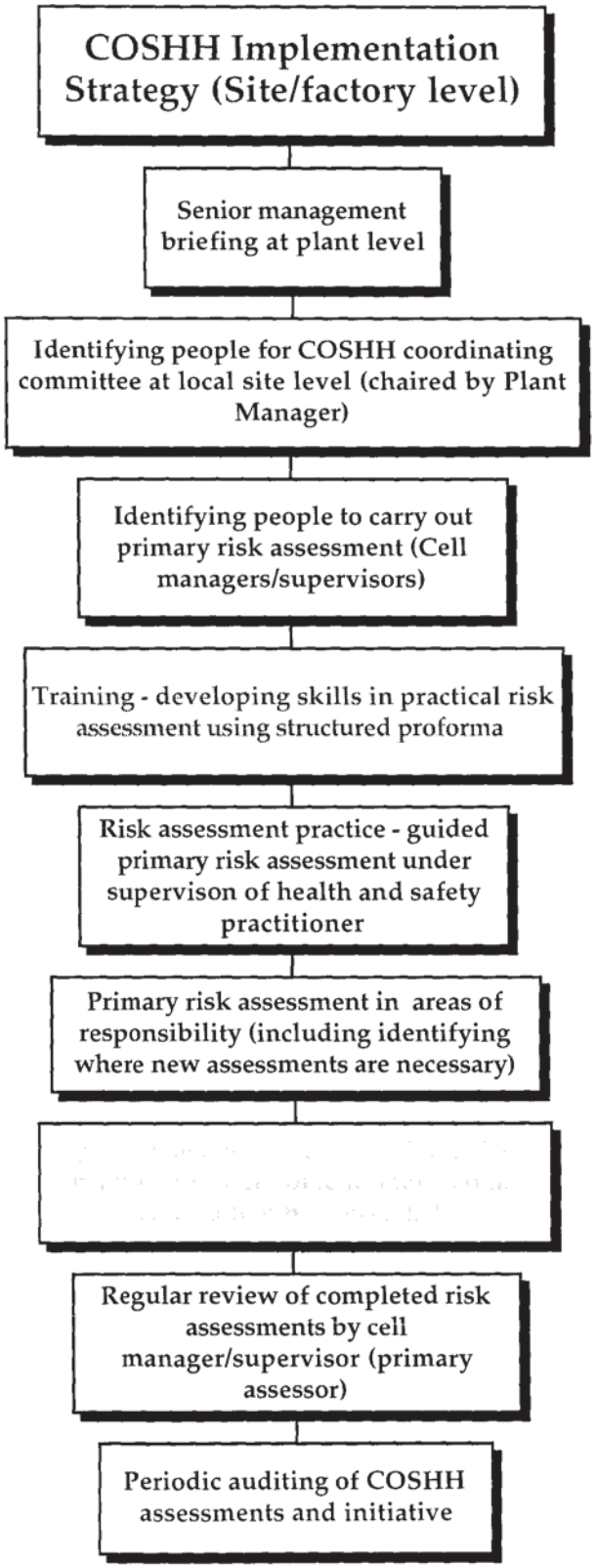
involving both senior line-management and technical support. At each factory site, a supporting COSHH co-ordinating committee was to be set up with the plant manager as chairman.

The underlying axiom of the strategy was that all primary risk assessments would be reviewed by a qualified health and safety specialist, who would decide whether further action was needed in a particular case. It was crucial that in areas with complex high risk processes, assessment situations were identified and addressed by appropriate specialists.

The central focus of the training was the use of a HSRA aid (a written proforma) which was designed to steer the assessor in a structured way through the basic stages of risk assessment. The proforma was supported by written guidance. During training in HSRA, managers were to be given extensive practice in using the proforma.

The strategy for COSHH implementation and training at factory/site level is summarised in the diagram (Figure 8.1) below:

Figure 8.1 Factory level strategy for COSHH implementation and training



8.2.1.1 Risk assessment training

The main objectives of the training were to:

- to develop confidence in departmental managers to enable them to carry out primary HS risk assessment;
- to provide practical experience in tackling risk assessment problems.

A further and important implicit objective of the training was to reinforce the view (supported by company policy) that it is the line manager who 'owns' toxic substance management in his/her area of responsibility. This was to counter the widely held (shopfloor) view that this task should be left for the 'expert' ie, the health and safety practitioner or occupational hygienist. Initial training commenced shortly before the enactment of the Management of Health and Safety at Work Regulations. The COSHH initiative was an important opportunity to develop ownership of health and safety hazards and risks in this wider context amongst managers.

8.2.1.2 HSRA Training Course (one day)

The content of the training course was as follows:

- occupational ill-health problems and the need for prevention;
- summary of the COSHH Regulations and management of risk from substances hazardous to health;
- methodology of risk assessment;
- risk assessment aid;
- practical risk assessment in groups;
- group discussion.

Following the introductory sessions, most of the time was spent in small groups practising applying the HSRA aid to case study situations.

8.2.1.3 Risk assessment proforma and pilot factory site

The aid was developed by the author following extensive discussions with company personnel, both in general management and health and safety. The design of the current version commenced from a basic model of HSRA activity.

A factory site was chosen for a pilot training course with the first version of the new proforma. Initially managers did not like the 'boxes' on the form, but this initial resistance was usually overcome as they acquired competency in the basic activity.

Following three training courses, the proforma was continually modified as a result of course participant comments. Several months later there was a review meeting of managers who had attended courses and who had commenced carrying out risk assessments. They were asked to comment on the helpfulness and ease of use of the proforma and guidance in practice. After incorporating these comments, it was decided that the optimum structure of the proforma had been reached. This version of the proforma and guidance is given in Appendix Three (page 359).

The early assessments of these managers were reviewed and checked for adequacy and omissions. Overall, the functioning of the training and proforma was concluded to be very satisfactory. The proforma was then introduced across the whole organisation and it is still in general use across the company.

Figure 8.2 Model for COSHH used in company training

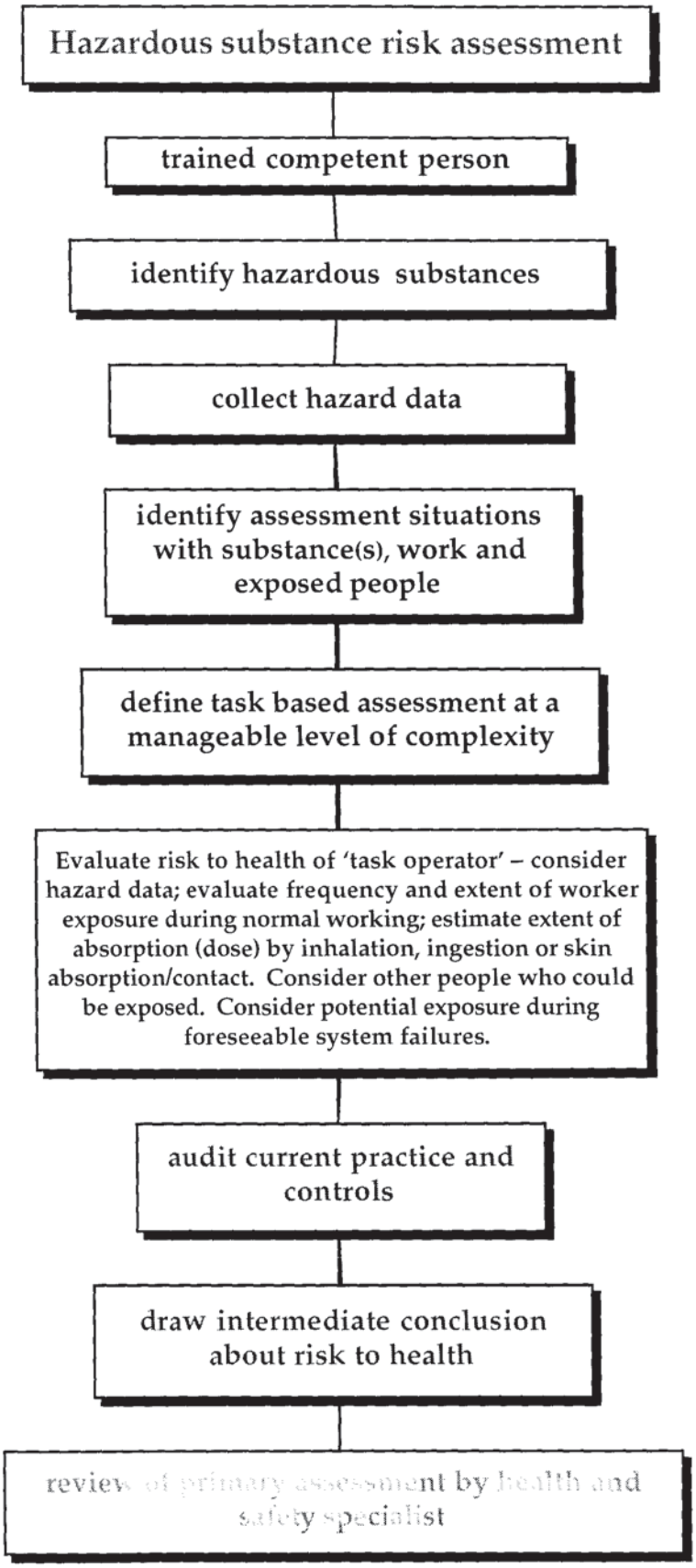
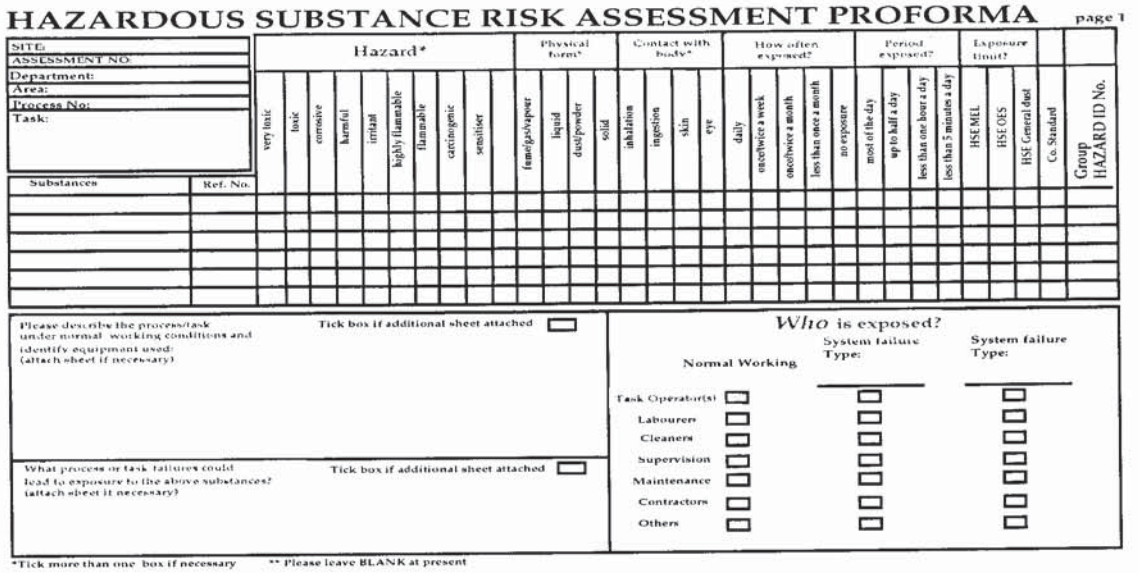


Figure 8.3 HSRA Proforma (full version in Appendix Three)



HAZARDOUS SUBSTANCE RISK ASSESSMENT PROFORMA page 1

SITE:
ASSESSMENT NO:
Department:
Area:
Process No:
Task:

Hazard*: very toxic; toxic; corrosive; harmful; irritant; highly flammable; flammable; carcinogenic; sensitiser

Physical form*: fume/gas/vapour; liquid; dust/powder; solid

Contact with body*: inhalation; ingestion; skin; eye

How often exposed?: daily; once/twice a week; once/twice a month; less than once a month; no exposure

Period exposed?: most of the day; up to half a day; less than one hour a day; less than 5 minutes a day

Exposure limit?: HSE MEL; HSE OES; HSE General dust; Co. Standard

Group HAZARD ID No.

Substances	Ref. No.

Please describe the process/task under normal working conditions and identify equipment used: (attach sheet if necessary)

Tick box if additional sheet attached ☐

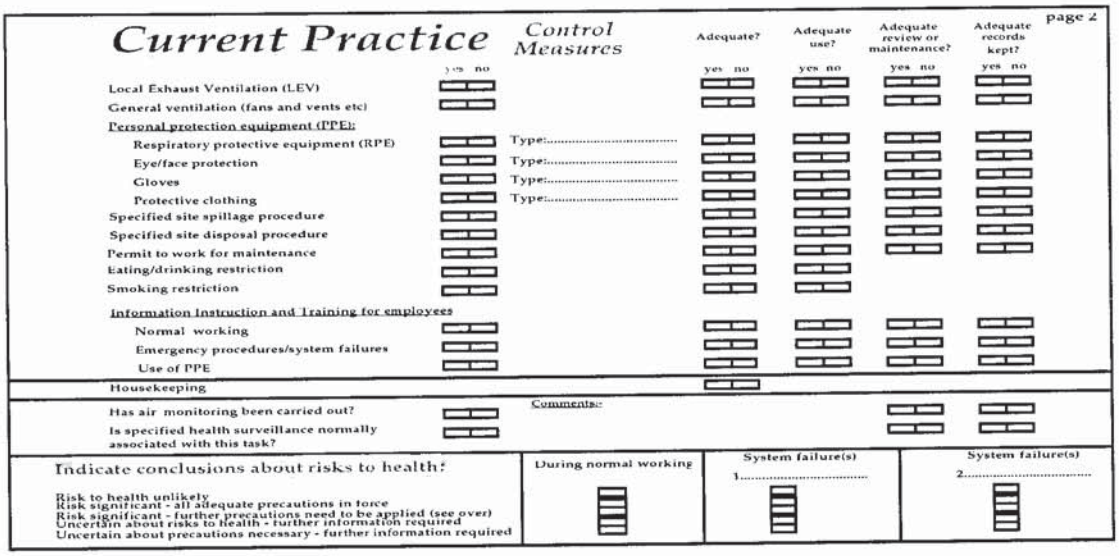
What process or task failures could lead to exposure to the above substances? (attach sheet if necessary)

Tick box if additional sheet attached ☐

Who is exposed?

	Normal Working	System failure Type:	System failure Type:
Task Operator(s)	☐	☐	☐
Labourers	☐	☐	☐
Cleaners	☐	☐	☐
Supervision	☐	☐	☐
Maintenance	☐	☐	☐
Contractors	☐	☐	☐
Others	☐	☐	☐

*Tick more than one box if necessary ** Please leave BLANK at present



page 2

Current Practice — *Control Measures*

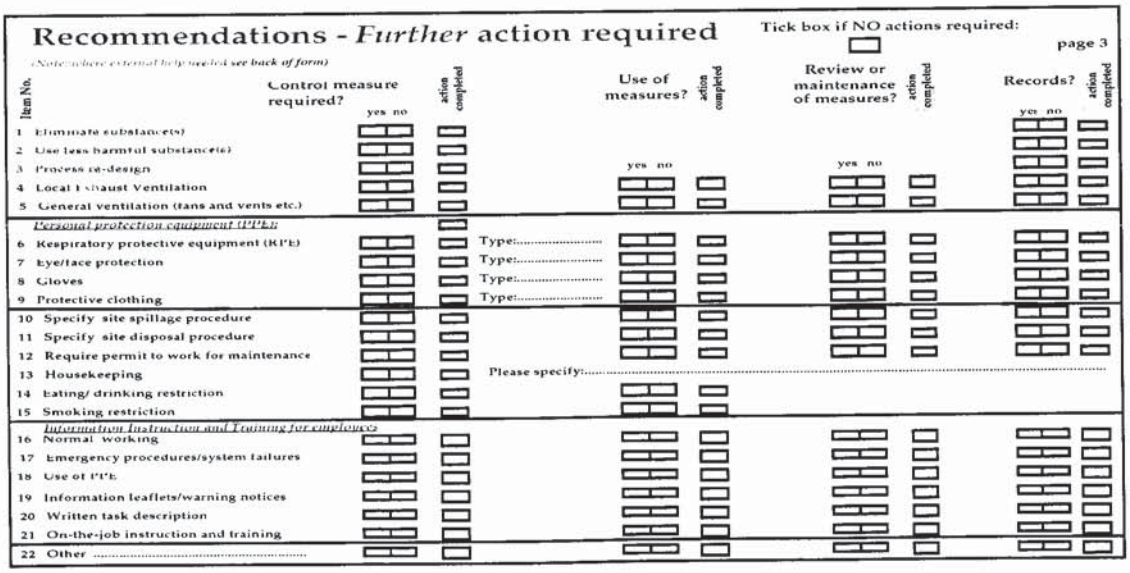
	yes	no	Adequate? yes	no	Adequate use? yes	no	Adequate review or maintenance? yes	no	Adequate records kept? yes	no
Local Exhaust Ventilation (LEV)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
General ventilation (fans and vents etc)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Personal protection equipment (PPE):										
Respiratory protective equipment (RPE)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Eye/face protection	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Gloves	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Protective clothing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Specified site spillage procedure	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Specified site disposal procedure	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Permit to work for maintenance	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Eating/drinking restriction	☐	☐	☐	☐	☐	☐				
Smoking restriction	☐	☐	☐	☐	☐	☐				
Information Instruction and Training for employees										
Normal working	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Emergency procedures/system failures	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Use of PPE	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Housekeeping			☐							
Has air monitoring been carried out?	☐	☐					☐	☐	☐	☐
Is specified health surveillance normally associated with this task?	☐	☐					☐	☐	☐	☐

Comments:

Indicate conclusions about risks to health:

Risk to health unlikely
Risk significant - all adequate precautions in force
Risk significant - further precautions need to be applied (see over)
Uncertain about risks to health - further information required
Uncertain about precautions necessary - further information required

During normal working	System failure(s) 1.....	System failure(s) 2.....
☐	☐	☐



Recommendations - *Further* action required

Tick box if NO actions required: ☐

page 3

(Note: where external help needed see back of form)

Item No.	Control measure required? yes	no	action completed	Type:	Use of measures? yes	no	action completed	Review or maintenance of measures? yes	no	action completed	Records? yes	no	action completed
1 Eliminate substance(s)	☐	☐	☐										
2 Use less harmful substance(s)	☐	☐	☐										
3 Process re-design	☐	☐	☐										
4 Local Exhaust Ventilation	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐
5 General ventilation (fans and vents etc.)	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐
Personal protection equipment (PPE):													
6 Respiratory protective equipment (RPE)	☐	☐	☐	Type:.....	☐	☐	☐	☐	☐	☐	☐	☐	☐
7 Eye/face protection	☐	☐	☐	Type:.....	☐	☐	☐	☐	☐	☐	☐	☐	☐
8 Gloves	☐	☐	☐	Type:.....	☐	☐	☐	☐	☐	☐	☐	☐	☐
9 Protective clothing	☐	☐	☐	Type:.....	☐	☐	☐	☐	☐	☐	☐	☐	☐
10 Specify site spillage procedure	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐
11 Specify site disposal procedure	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐
12 Require permit to work for maintenance	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐
13 Housekeeping	☐	☐	☐	Please specify:.....									
14 Eating/ drinking restriction	☐	☐	☐		☐	☐	☐						
15 Smoking restriction	☐	☐	☐		☐	☐	☐						
Information Instruction and Training for employees													
16 Normal working	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐
17 Emergency procedures/system failures	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐
18 Use of PPE	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐
19 Information leaflets/warning notices	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐
20 Written task description	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐
21 On-the-job instruction and training	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐
22 Other	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐

8.2.1.4 Task-driven risk assessment

The proforma aims to structure a path for managers to follow in carrying out risk assessment. (Its use involves a lot of 'ticking boxes'.) In this case the assessment process is task-driven (as opposed to substance-driven), which was more practicable in a manufacturing production context. The first stage requires the user to identify the exact location of the process/task under consideration. By task analysis, the assessor has to break the process down into a series of tasks of 'manageable complexity' in order draw a conclusion on tolerability of risk to the 'task operator' – ie, not too complex, or it is difficult to come to a conclusion on health risk, or too simple, since this will involve too many separate task risk assessments.

8.2.1.4.1 Substances hazardous to health

Once the task has been defined, then substances hazardous to health are listed and hazard data obtained. The manager searches out and reads the hazard information and ticks relevant boxes on the form.

8.2.1.4.2 Task operator

There are some questions relating to the extent of a task operator's exposure (ie, how often exposed, and period of time exposed?) Primarily, it is the designated 'task operator' who is of concern and it is this person about whom a conclusion on risk tolerability will be drawn. The proforma collects information on who could be exposed in addition to the nominal task operator. This may indicate that further assessments are needed from the viewpoint of other worker groups, for example, maintenance or cleaning personnel.

8.2.1.4.3 Normal working and system failures

The proforma requires the assessor to reach a conclusion on health risk considering both normal working conditions and conditions of foreseeable system failure. The assessor is encouraged to think about ways in which the designated task could fail or break down, and if these contingencies occurred, to consider what would be the consequences in terms of exposure and risk

tolerability. Occasionally, this may indicate that the assessor needs to carry out a full separate assessment on the predicted contingency or failure occurring.

8.2.1.4.4 Evaluating and auditing current controls

Having collected information on substances, task and person(s) exposed, the assessor now briefly audits current control measures from the point of view of their theoretical adequacy, adequate use, maintenance. Following this, a conclusion is drawn on the tolerability of risk to the task operator.

The aid gives five general options for conclusions:

- risk to health unlikely
- risk significant - all adequate precautions in force
- risk significant - further precautions need to be applied
- uncertain about risks to health - further information required
- uncertain about precautions - further information required

A conclusion on tolerability of risk leads to recommendations for action (if appropriate). The proforma facilitates the production of an action plan. During training, the managers were asked to critically review assessment proformas from other organisations in order to build up perspective on the requirements of HSRA. This exercise highlighted proformas where there was a requirement to 'tick boxes' and those where most structuring of input was left to the assessor. (The latter assumed a greater level of assessor expertise than the former).

8.2.2 CONCLUSIONS

1. The COSHH training and implementation strategy provided an excellent opportunity to gain insight into the needs of managers charged with carrying out HSRA. This was provided both from discussions on the design of the proforma and the comments and observations by managers during the training courses.

2. The risk assessment proforma was accepted by the managers and found to be helpful and usable.

3. Mandatory reviews of assessments and subsequent auditing, demonstrated that departmental managers, following training, were competent to carry out primary HSRA in their areas.

8.2.3 POSTSCRIPT

At the pilot factory site completed assessment forms were examined and it was found that generally the managers were carrying out competent primary HSRA. Further reviews since this time have indicated that this is still the case.

Finally and importantly, managers accepted that it was part of their responsibilities to manage toxic substance hazards and risks and subsequently, many underwent further training for the risk assessments required for compliance with the Management of Health and Safety at Work Regulations 1992. The COSHH initiative had laid the foundations of a risk assessment culture within this group of managers, which facilitated their acceptance and ownership of this wider risk assessment role.

8.3 ORGANISATION Y

8.3.1 APPROACH TO HSRA AND TRAINING

This is included to contrast the approach of a small non-industrial organisation to complying with the requirements of the COSHH Regulations. Organisation Y was a social club. Concern had been expressed by a visiting environmental health officer about storage and use of cleaning substances at the club's premises.

Initially, the author had a meeting with two members of the management committee and it was decided that the author would look at the use of substances in the club, hold a short training session and design a simple proforma for (COSHH) risk assessment (Appendix Three).

This proforma was intended to be as brief as possible but again to guide the designated assessor through the rudiments of the process. The objective was that in the designated assessor at the club would carry out this activity for the substances used. Following basic training, one member of the management

committee undertook the risk assessment task. This person then looked at the management of toxic substances on the premises. This involved training the team of cleaners in storage practice and in the use of adequate personal protective equipment.

8.3.2 CONCLUSIONS

This organisation and its employees took health and safety and risk assessment more seriously than they had previously and a later check indicated that the simple proforma worked well in its context.

8.4 OVERVIEW

The contrast is made between the two very different organisations both of which had to comply with the same legal regulations. It emphasises that the approach to risk assessment needs to be flexible and that each organisation needs to adopt the system which best fits its own circumstances. This also illustrates the benefits of non-prescriptive legislation in achieving compliance in very different organisations.

9.

General Model for Hazardous Substance Risk Assessment

9.1 DEVELOPMENT OF HSRA MODEL B

This Chapter outlines the development of a general model for hazardous substance risk assessment based upon work described previously in this thesis (Figure 9.1). The HSRA model itself is detailed in Figure 9.2, below and described in this Chapter. A model was needed for two purposes:

- To capture the process of the approach of occupational hygienists to HSRA for use as a guide for non-experts and for their training;
- To structure the analysis of results in the videotape KE study (Chapter Eleven).

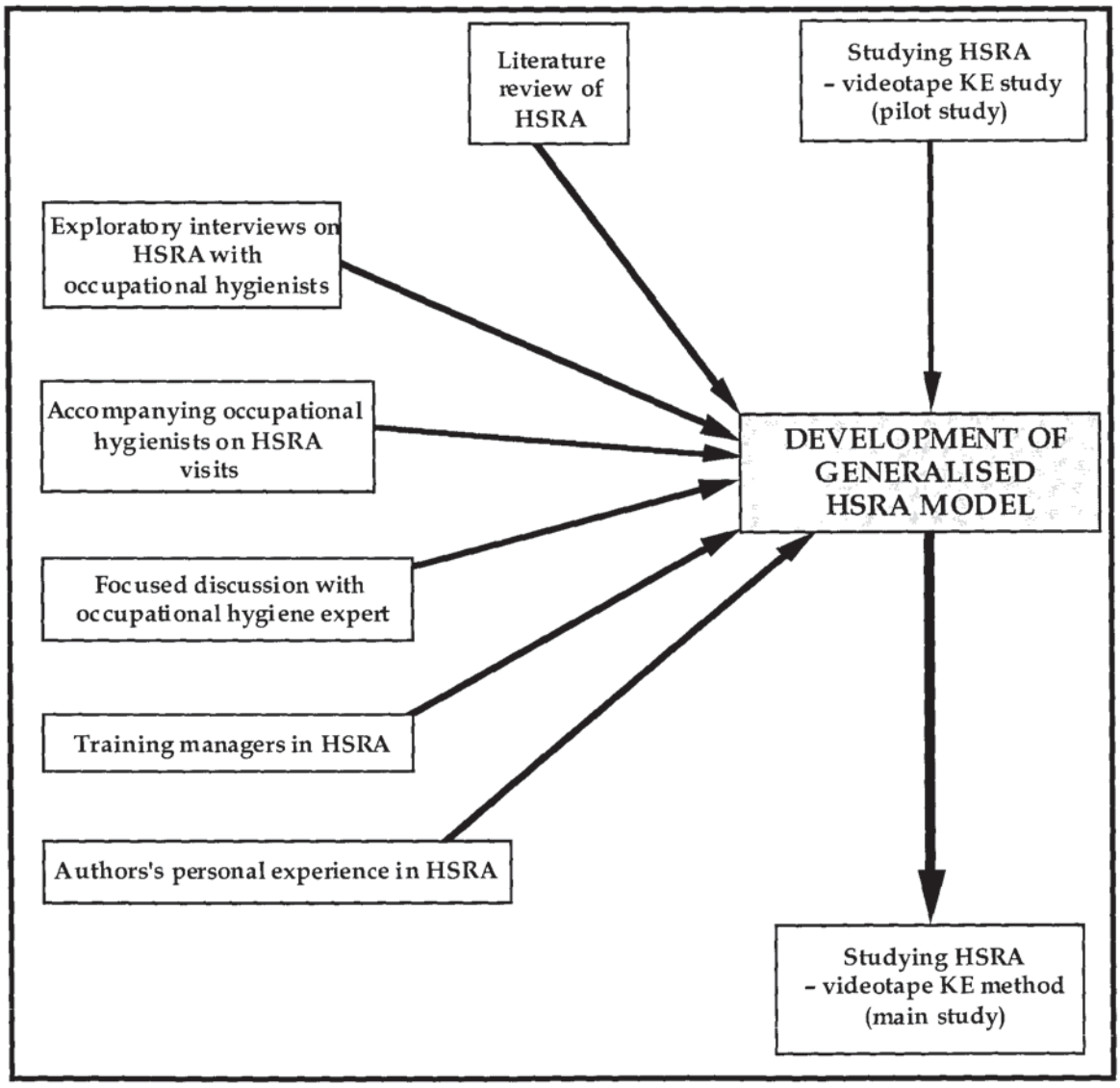
It was necessary for the model to be adaptable, since the scope and purpose of the HSRA activities embodied in these objectives differ, ie, the first covers the comprehensive risk assessment task in the 'real world' whilst the second encompasses a walk-through risk assessment with constraints imposed by the experimental method.

In the next section, there are definitions of the terminology used, which is followed by a brief description of the stages shown in Model B. (In the discussion reference is made to HSRA Model A (Chapter Seven) in order to show the common aspects between the two models.)

The key definitions are:

- process – a self-contained set of tasks and operations;
- task – a useful level of detail for activities that individuals undertake;
- workgroup – people doing similar work exposed to the same sources to a similar degree.

Figure 9.1 Derivation of HSRA Model B (as Figure 4-1)



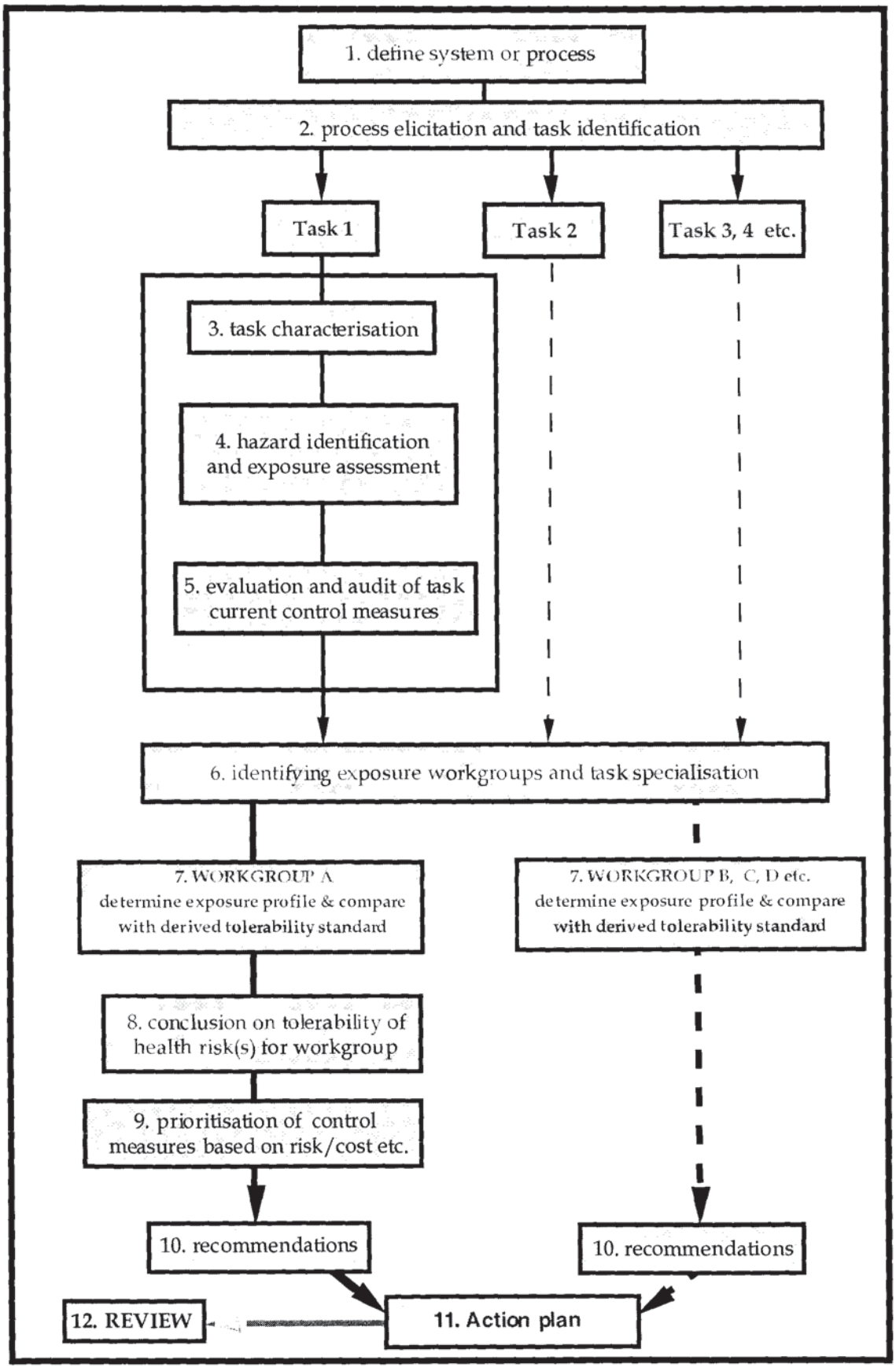


Figure 9.2 HSRA Model B

9.2 OUTLINE DESCRIPTION OF MODEL

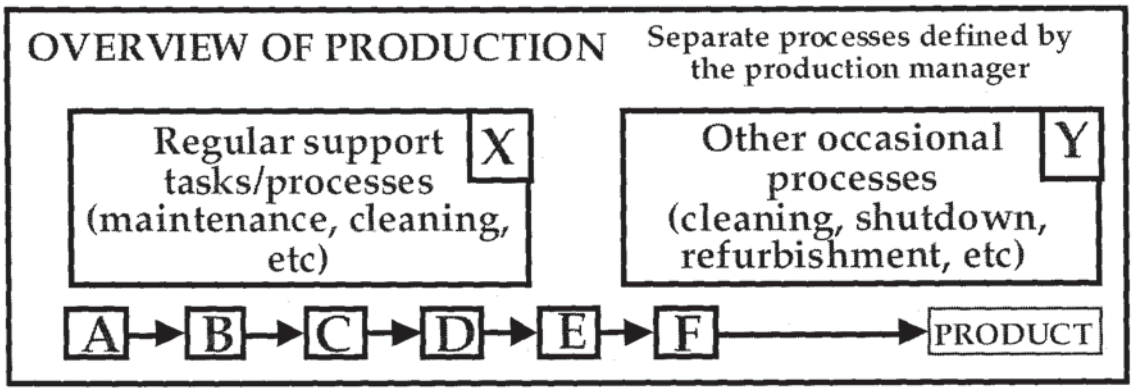
9.2.1 DEFINE SYSTEM OR PROCESS (STAGE 1)

The assessor defines the system or work process upon which HSRA is to be carried out.

9.2.2 PROCESS ELICITATION AND TASK IDENTIFICATION (STAGE 2)

This is the process by which the risk assessor initially identifies the relevant stages or tasks in the production process. This then allows essentially task-driven risk assessment to proceed.

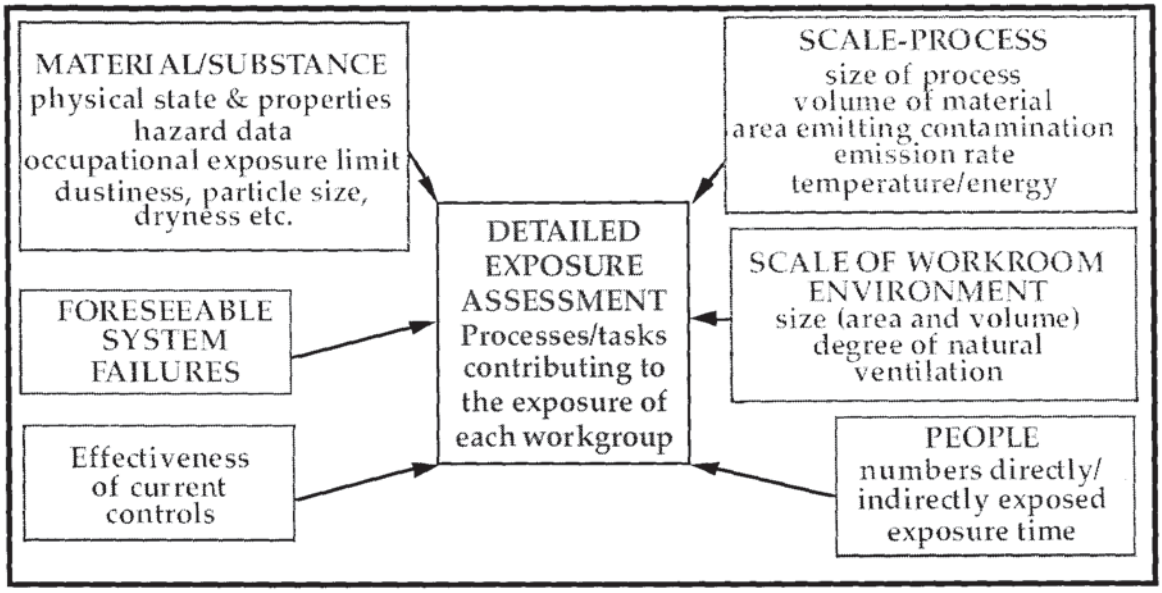
Figure 9.3 Process Elicitation and Task Identification



It is crucial that all relevant tasks are identified otherwise hazard identification and risk assessment will be incomplete. In the diagram the existence of tasks A-F (inclusive) and X/Y has to be determined by the assessor.

(Stages 3-8 of Model B represent a 'detailed workgroup exposure assessment,' as outlined in Model A from Chapter Seven with some additional features. These steps are carried out for all the processes/tasks for each workgroup and involves collection of the following type information shown in Figure 9.4. below.)

Figure 9.4 Detailed exposure assessment



9.2.3 TASK CHARACTERISATION (STAGE 3)

This involves eliciting information about principally about technical aspects of processes and tasks:

- task method/specification;
- substances and preparations used;
- chemical and physical properties of substances;
- rate of consumption of substances;
- temperature/pressure of process;
- machinery/equipment used;
- task and process times (frequency of task for non-continuous processes).

9.2.4 HAZARD IDENTIFICATION AND EXPOSURE ASSESSMENT (STAGE 4)

Where possible, further information about a process and associated tasks can be obtained by observing the work. Such information could include, for example:

- the identification of task/operator characteristics;
- identification of inhalation hazards (Is there a smell in the work area? Is a dust aerosol generated? Are the substances volatile? Are substances spread over large surface areas? Observing the physical dimensions of emitting source(s) and the proximity of exposed persons);
- identification of skin contact hazards. (Is there contact between substances and unprotected skin?);
- identification of ingestion hazards (Do people eat in the work area? Are there adequate washing facilities?);
- identification of control and protective measures;
- observing the physical nature and size of the task environment;

(This can be the starting point for integrated risk assessment involving the identification of other (non-substance) hazards.)

Other information on the nature of a task can be elicited by questioning management, technical specialists and members of the workforce particularly the 'task operator'. This is the person who principally carries out the task in question.

- obtaining manufacturer/supplier's product hazard data sheets;
- is there any indication of health effects/complaints in exposed workers;
- foreseeable task failures (At this point the assessor considers potential task failures and the implications for hazard exposure, for example, spillage of material or failure of a key control measure).

Further, where visual task assessment is sometimes not possible (for example, with batch processing), then the assessor may have to elicit key information *verbally* from discussion with employees or managers.

9.2.5 EVALUATION AND AUDIT OF TASK CURRENT CONTROL MEASURES (STAGE 5)

This involves considering prospective control measures including: general and local exhaust ventilation systems, various types of personal protection equipment and provision of information, instruction and training for

employees. The assessor needs to address the following questions for each control measure considered (derived in part from Bensiali *et at.* 1987):

- is the control measure currently applied? (ie, Does it exist?);
- is the control measure (theoretically) adequate?
- is the control measure adequately used?
- is the control measure adequately maintained (reviewed if a procedure)?
- are adequate records kept relating to the control measure?

At this stage the assessor may also ask questions about health and safety management overall, as an indication of standards and the general level of hazard control at the company. For example,

- has the company got a health and safety policy?
- do the workers have any training/information for health and safety?
- what is the manager's attitude to health and safety?

9.2.6 IDENTIFYING EXPOSURE WORKGROUPS AND TASK SPECIALISATION (STAGE 6)

As defined above, a workgroup consists of people doing similar work exposed to the same sources to a similar degree. In other words they carry out a similar group of process tasks. Employees are grouped on the basis of their exposure to hazardous substances and task specialists are identified. The exposure of different workgroups, such as production operators, labourers, maintenance staff and cleaners should be considered.

9.2.7 DETERMINING WORKGROUP HAZARD EXPOSURE PROFILE AND COMPARING WITH TOLERABILITY STANDARD (STAGE 7)

This is the identification of typical workgroup hazard exposure profiles. For inhalation exposure, this usually in terms of an estimated (or measured) eight-hour or fifteen minute time-weighted average breathing zone concentrations.

The estimated exposure profile is compared with the derived tolerability standard. Sometimes derived tolerability standards do not exist for inhalation exposure to substances. In this case the assessor may either devise their own standard or in some cases it is pragmatic to look for indicators of 'unacceptable exposure'.

For inhalation exposure, the COSHH Regulations define 'adequate control' for selected substances by Maximum Exposure Limits or Occupational Exposure Standards (Chapter Two). The assessor compares exposure profiles with these limits or in the case of unclassified particulates, with the HSE's 'general dust' standard. From the author's experience and the interviews carried out in this study (Chapter Five), practitioners work, as a rule of thumb, to an air contaminant level represented by 25-50% of the concentrations embodied in these limits. Although, strictly this is not appropriate for the MEL standards, since exposure concentrations must be reduced as far as is reasonably practicable to comply with the legal duty. As well as inhalation hazards the extent and pattern of skin contact/absorption and ingestion exposure are considered at this stage. This is normally more of a qualitative rather than quantitative assessment.

A list of indicators of 'unacceptable exposure' is given in Table 9-1 below:

Table 9-1 Indicators of 'unacceptable' exposure

- non-compliance with MEL limits
- non-compliance with OES limits (in excess of 25%)
- non-compliance with the HSE general dust standard (in excess of 25%)
- evidence of acute health effects in workers connected with exposure
- consistent complaints from workers of associated odour or discomfort
- evidence of sensitisation particularly in the respiratory system or skin
- ingestion of substances
- significant eye contact with substances
- significant skin contact with/absorption of substances
- regular unprotected exposure for long periods of time

9.2.8 CONCLUSION ON TOLERABILITY OF HEALTH RISK FOR EACH WORKGROUP (STAGE 8)

The assessor reaches a conclusion on risk for each workgroup. HSE Authoritative guidance (HSE, 1988) is utilised in a modified form following the comments of industrial managers during the HSRA training described in Chapter Eight. The following categories were found to be preferable as conclusions on risks to health:

- risks to health unlikely;
- risks significant - all adequate precautions in force;
- risks significant - further precautions need to be applied;
- uncertain about risks to health - further information required;
- uncertain about precautions necessary - further information required.

9.2.9 PRIORITISATION OF CONTROL MEASURES BASED ON PERCEIVED RISK/COST (STAGE 9)

For each workgroup, the assessor now ranks tasks and control measures based on perceived risks, feasibility and costs (See Figures 9-5 and 9-6.) In reality this is a complicated process as is shown in from the model developed in Chapter Seven.

Figure 9.5 Control and the dialogue box

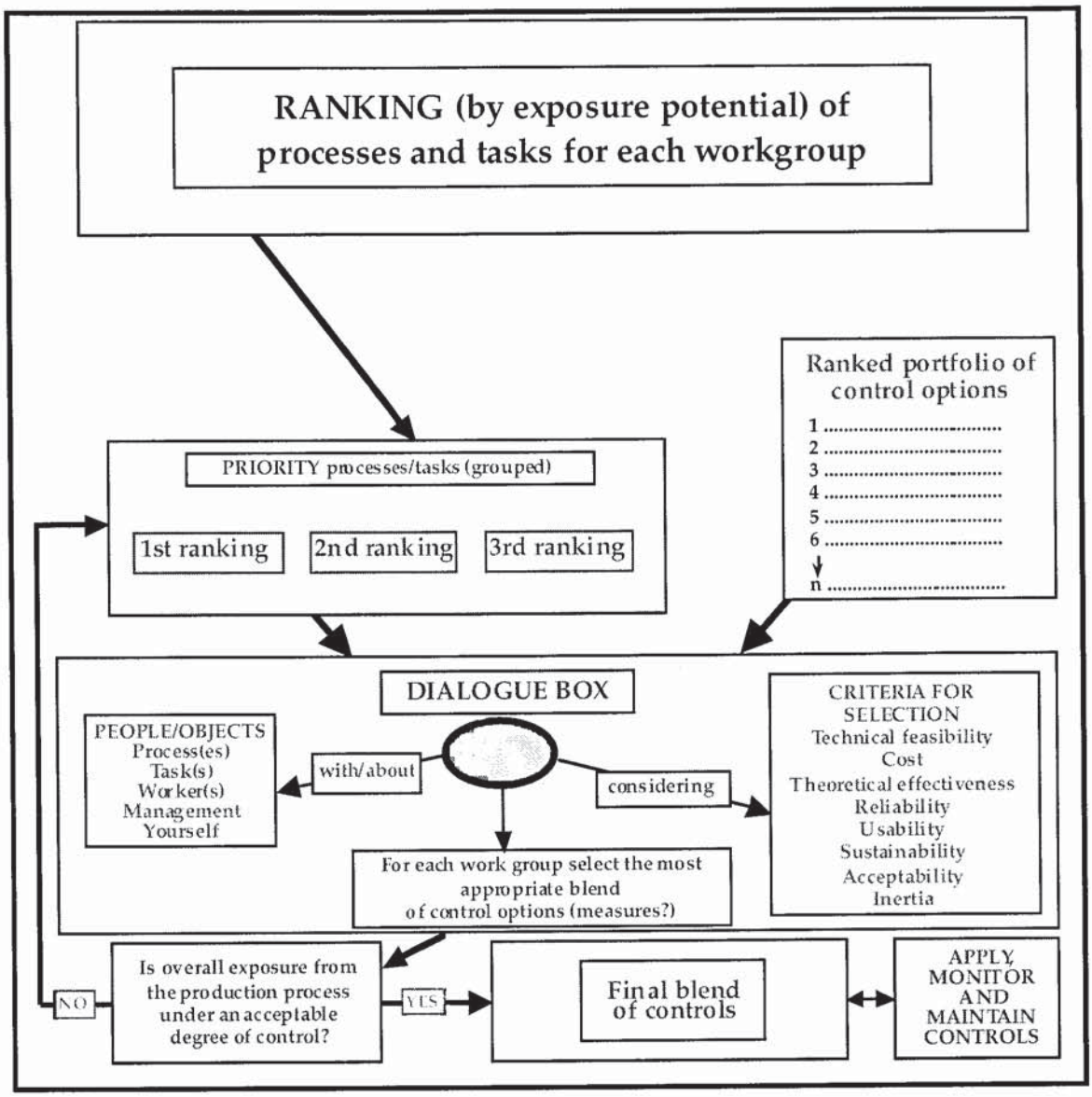
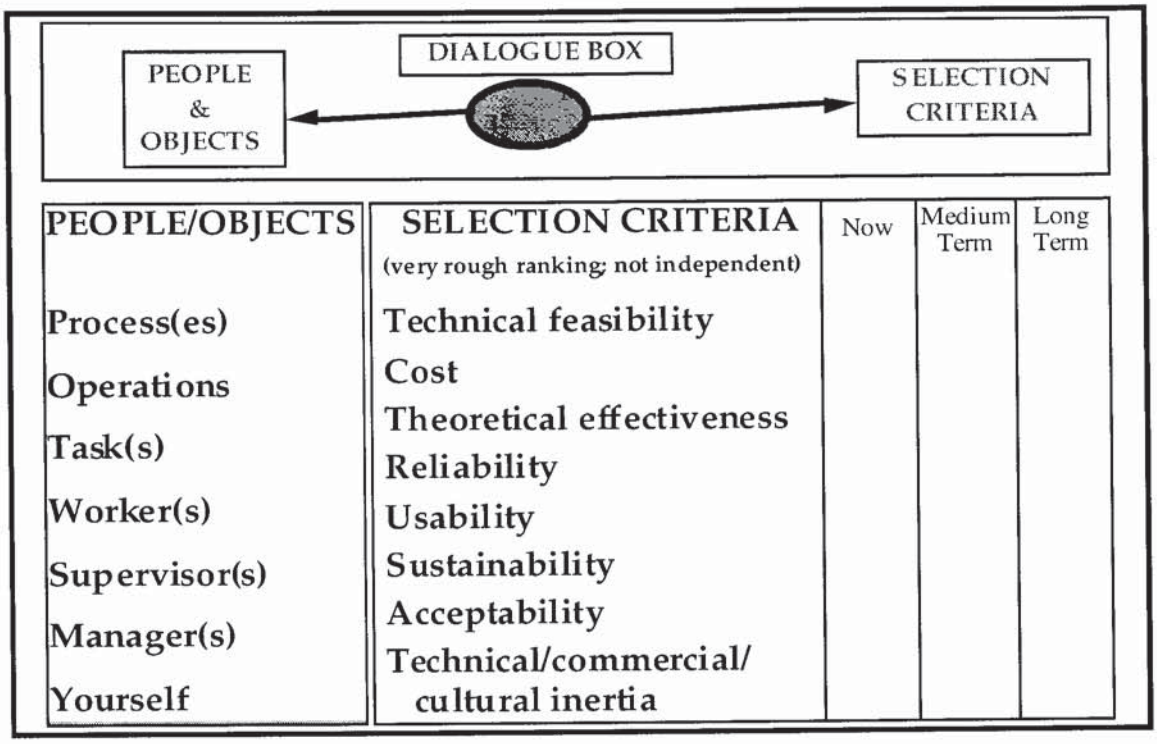


Figure 9.6 Dialogue box detailed factors



PEOPLE/OBJECTS	SELECTION CRITERIA (very rough ranking; not independent)	Now	Medium Term	Long Term
Process(es)	Technical feasibility			
Operations	Cost			
Task(s)	Theoretical effectiveness			
Worker(s)	Reliability			
Supervisor(s)	Usability			
Manager(s)	Sustainability			
Yourself	Acceptability			
	Technical/commercial/ cultural inertia			

9.2.10 RECOMMENDATIONS (STAGE 10)

With the above dialogue box, in the case of each workgroup the most appropriate blend of control measures is selected. This involves applying the portfolio of control options to each workgroup and their task(s) to achieve optimal control of exposure. This would be translated into recommendations for each workgroup.

9.2.11 ACTION PLAN (STAGE 11)

This integrates the recommendations for the individual workgroup exposure assessments and control recommendations into an overall action plan to cover the whole process activity.

9.2.12 REVIEW (STAGE 12)

After a suitable period of time the whole risk assessment and control process should be reviewed and audited.

9.3 COMMENTARY

As discussed in Chapter Seven, it is not believed that hygienists keep strictly to the sequential logic of the diagram but that this represents steps for which information needs to be collected.

Model B is used as the basis for the classification and performance matrix used in Chapter Eleven, which is used in the structuring of findings and applied in scoring of participants in the risk assessment exercise.

10.

Knowledge elicitation: risk assessment videotape case-study – method

10.1 INTRODUCTION

Following the pilot study described in Chapter Seven, the method was modified slightly and applied to other groups of health and safety specialists. In this wider study safety practitioners, occupational health physicians and occupational health nurses were included as well as new groups of occupational hygienists and trainee inspectors.

The objectives of the protocol were to:

- evaluate the effectiveness of this method as a useful knowledge elicitation technique;
- investigate and characterise the approach occupational hygienists used in hazardous substance risk assessment;
- investigate the approach of other groups of occupational health and safety specialists.

The pre-interview oral/written briefing was modified and this time participants were not asked to 'talk aloud' during the initial viewing of the videotape. As discussed above, the pilot study revealed that this did not contribute helpful information (Chapter Six).

It was decided that participants should watch the tape at least twice. The first viewing was intended to give the participant a general impression of the

factory, processes and tasks. They would be specifically requested not to ask questions until the tape had finished. Before commencing, and during the second viewing, participants would be able to ask questions. In addition, they would be given the video-player remote control whereby they could stop, rewind or fast forward the tape at will (ie, they had the means to navigate around the tape.) It was intended that this would be more like a real factory visit where the assessor normally has some control. In the consultations they could now ask questions in more detail whilst holding the tape at an appropriate point. All further information about the process was still to be obtained through the 'factory manager'.

10.2 METHOD

10.2.1 THE VIDEOTAPE CASE-STUDY

The GRP factory videotape, as used in the pilot study, was used in the extended study. The criteria used in the selection of the particular tape sequence were described in Chapter Four (page 118).

10.2.1.1 Background

At the request of company management, the author visited a small factory in the West Midlands engaged in the manufacture glass-reinforced plastic doors. This followed a routine visit by a local Health and Safety Executive inspector, who had asked the company to undertake monitoring of the exposure of workers to styrene vapour. Whilst carrying out this monitoring exercise, the author was given permission to make a short videotape to illustrate process tasks and systems of work at the factory. From a detailed discussion with the workshop supervisor, a full process description was elicited by the author, who also obtained copies of manufacturers' health and safety data sheets for the hazardous substances in use. This information formed the basis of the videotape scenario and the role of the 'surrogate' factory manager.

The factory concerned was part of a small locally-based group of companies. There was no in-house specialist with health and safety expertise. The real manager of the factory featured in the videotape had minimal formal health

and safety training, and with the exception of fire risks had little knowledge or apparent interest in health and safety.

Health and safety standards in the factory were poor, as revealed by the videotape, with explicit demonstration of various hazards. The factory production area was a one-storey brick building with a high wooden roof, consisting of one major work area with several minor annexes. Not featured in the videotape were an adjoining small mess room, the washroom and the finishing shop. The factory building had little provision for ventilation. The major activity was the production of moulded GRP products (mainly doors) and the workers portrayed were full-time 'moulders' engaged in various activities. The 'finisher' worker was not working on the day of filming and was therefore not captured on the tape.

10.2.1.2 Content of the videotape

Aspects of the work process and tasks illustrated are:

- polishing the mould pattern (base upon which the moulding is built up);
- mould pattern repair work;
- laying-up or lamination involving glass fibre sheet and the brush application of polyester resins;
- the cutting up and handling of glass fibre sheet.

The principal hazardous substances in use are styrene-based polyester resins, glass fibre matting, epoxy resins (in mould pattern repair work), an organic peroxide catalyst for activating the resins, various xylene-based paints, acetone and various other organic solvents.

Not featured in the videotape are the mixing process (activation of the resin with the catalyst) and the finishing process involving the use of a power sander to produce the final product.

The GRP process steps are given below (Figure 10.8, page 227) and there are further details in the Tables following. Further, a full written description of the videotape sequence is given in Appendix 14.7 (page 377).In order to give a

visual impression of the videotape and the factory featured, photographic stills have been produced from the tape. These are presented as Photographs 10-1 to 10-9 on pages 207, 208 and 209 below.

Figure 10.1

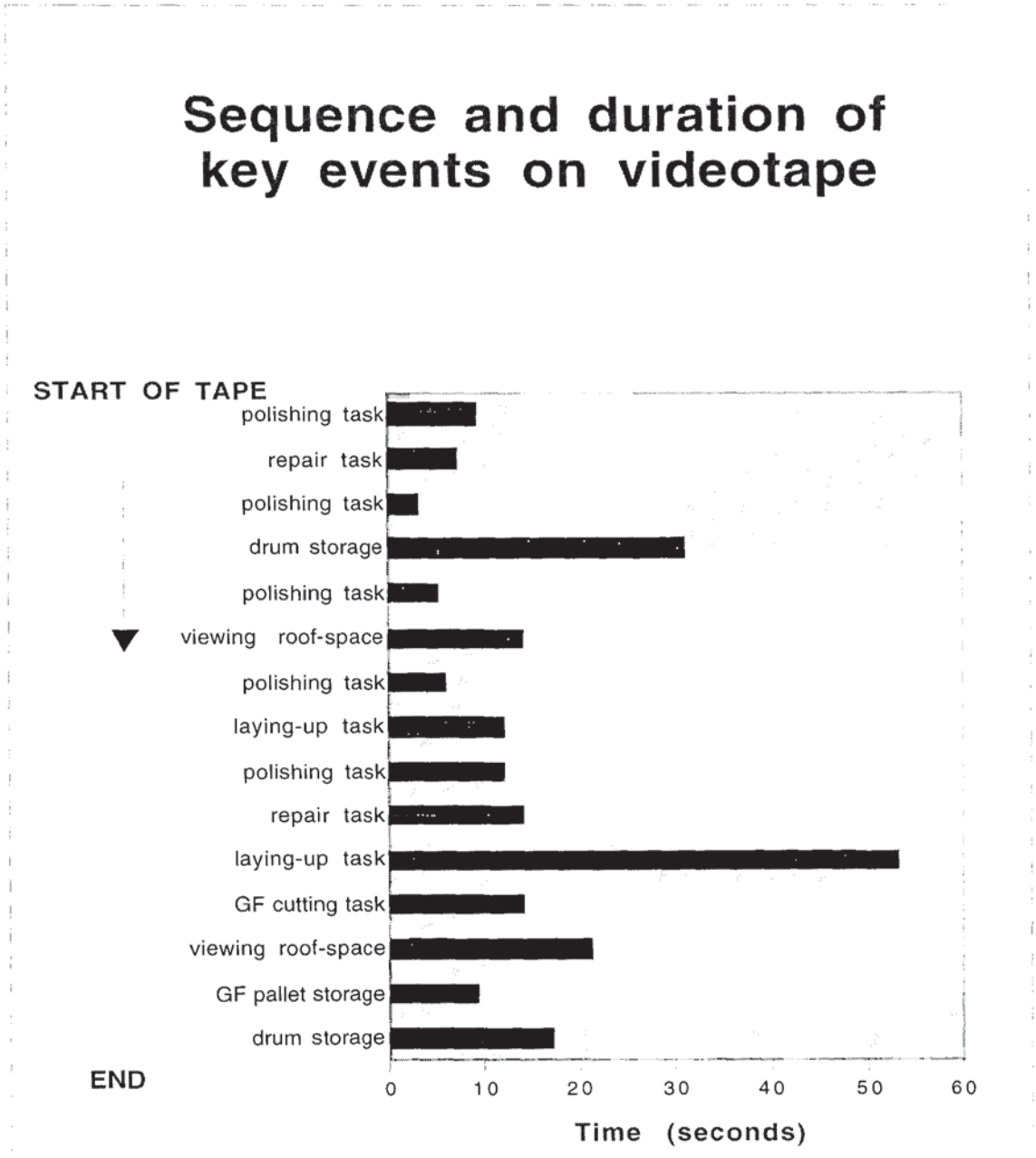
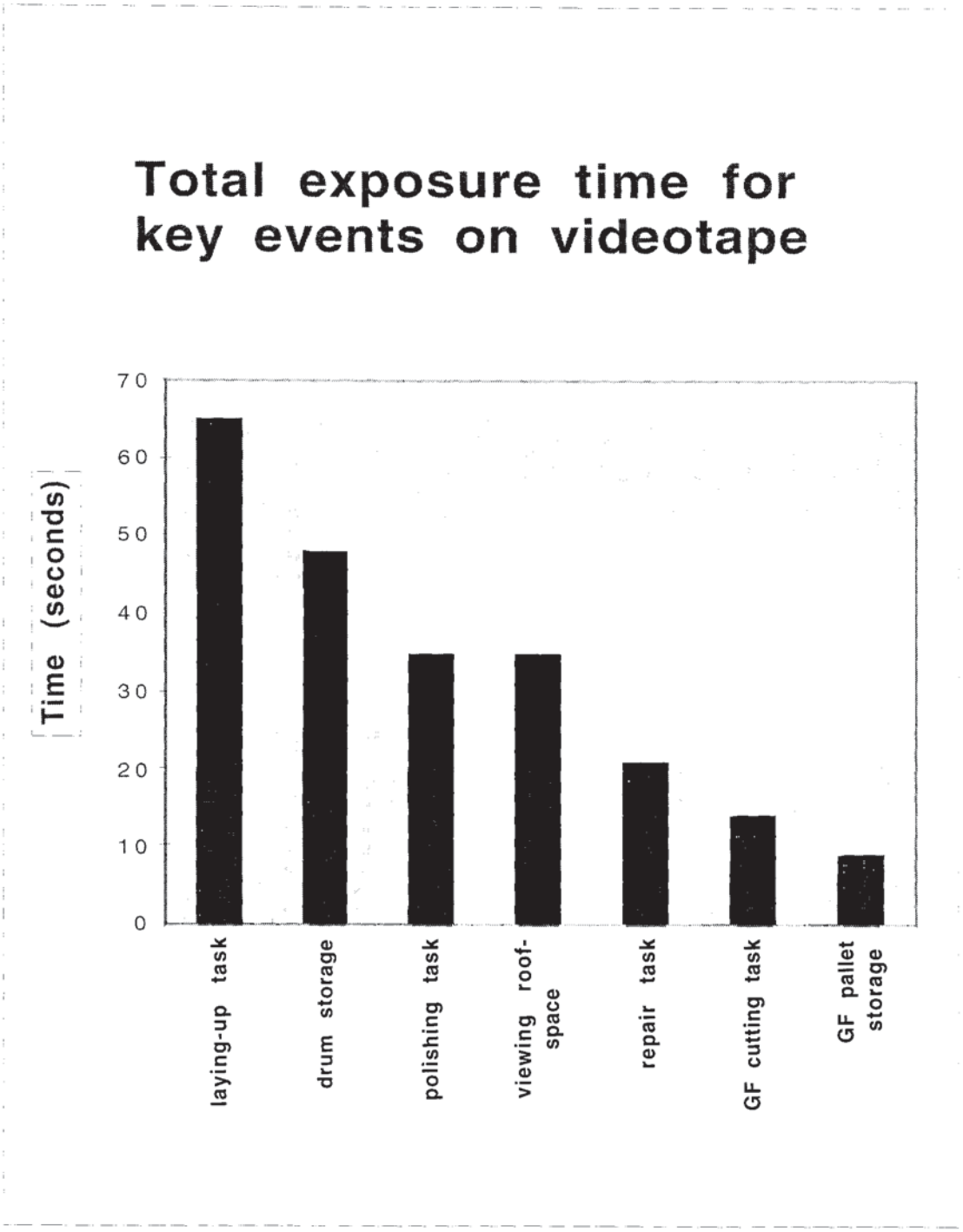
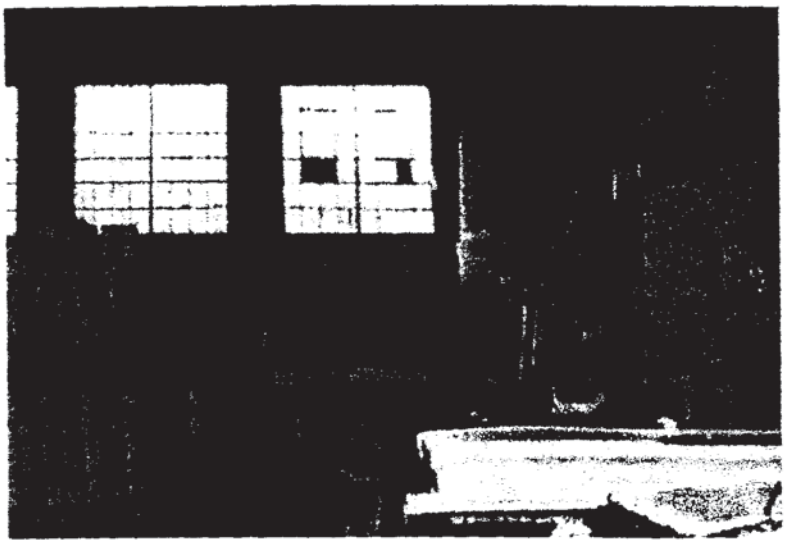
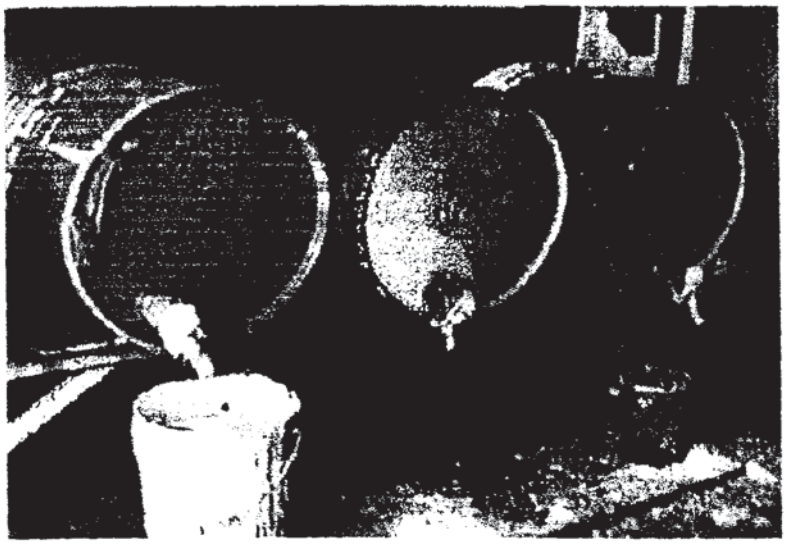


Figure 10.2


Total exposure time for key events on videotape
Time (seconds)
70
60
50
40
30
20
10
0
laying-up task
drum storage
polishing task
viewing roof-space
repair task
GF cutting task
GF pallet storage



PHOTOGRAPH 10.1 - GRP MOULDING

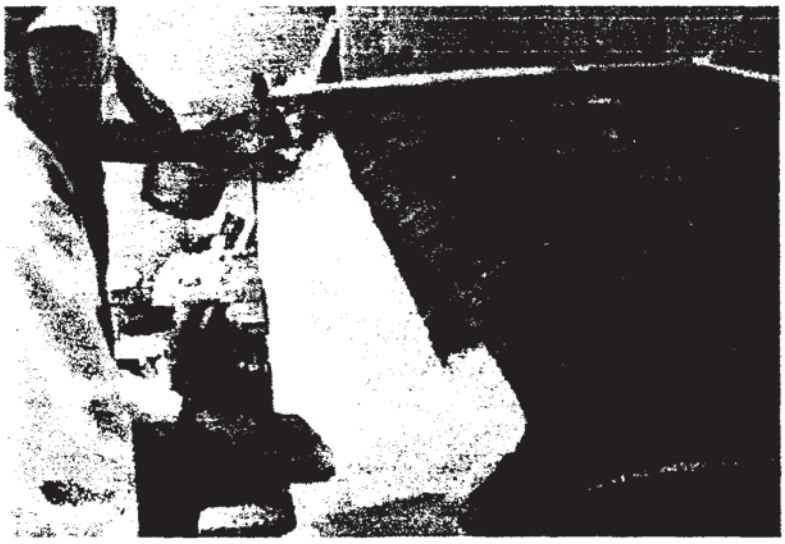


PHOTOGRAPH 10.2 - RESIN DRUM STORAGE I

PHOTOGRAPH 10.3 - RESIN DRUM STORAGE II

PHOTOGRAPH 10.4 - PREPARATION OF MOULD PATTERN - POLISHING

PHOTOGRAPH 10.5 - CUTTING GLASS FIBRE SHEET



PHOTOGRAPH 10.6 - LAYING UP RESIN AND GLASS FIBRE

PHOTOGRAPH 10.7 - REPAIRING MOULD PATTERN

PHOTOGRAPH 10.8 - BEVERAGE CONSUMPTION IN WORK AREA

PHOTOGRAPH 10.9 - FACTORY ROOF

10.2.2 SELECTION OF PARTICIPANTS

It soon became clear that it was not possible to obtain random statistical samples from populations of occupational hygienists, occupational health nurses, occupational health physicians, health and safety practitioners and trainee health and safety inspectors because of geographical, time and other constraints including willingness to participate in the study. In this context it was thought crucial that the participants selected, or who selected themselves, are described in detail below (Table 10-1). By their anonymity, findings can be related to the experience of each participant.

As key objectives were to evaluate the method and differences between the groups, where possible, local representatives of the specialist groups were identified and recruited as participants. However, it was very important to have volunteers with a willingness to participate. (Subsequently, in the study only one person felt unable to enter into the spirit of the role-play exercise.)

Tape transcripts were produced for each consultation. The experimental groups were selected on the basis of job title, qualifications and relevant experience. Five groups of health and safety specialists were represented, namely:

- occupational hygienists (12)
- health and safety practitioners (10)
- occupational health physicians (9)[7]
- occupational health nurses (10)
- trainee health and safety inspectors (10)

[7] The content of one consultation was lost due to tape failure.

10.2.2.1 Occupational hygienists

A typical group of experienced occupational hygienists was recruited for the study. The author was previously acquainted with some members of the group and other participants were identified from the membership list of the British Occupational Hygiene Society. Initial contact was normally by telephone although on one occasion the project was introduced by letter. The profile of the group is summarised below and in Table 10-1.

Qualifications

- five participants had degrees in occupational hygiene (four of these at Master's level):
- four had the Diploma in Occupational Hygiene from the British Examining Board in Occupational Hygiene;
- one person had both a Master's degree in Occupational Hygiene and the Diploma in Occupational Hygiene;
- two did not have formal qualifications in occupational hygiene (but had corporate membership of the Institute of Occupational Hygienists.)

Professional Bodies

- all were corporate members of the Institute of Occupational Hygienists.

Experience

- all had considerable experience in practical occupational hygiene averaging 15 years;
- all were working as occupational hygienists, although one person had recently retired, and two participants were full-time consultants.

10.2.2.2 Health and safety practitioners

A typical group of experienced health and safety practitioners was recruited for participation in the study. The author was previously acquainted with

some members of this group, whilst others were identified by third party contacts and with assistance of the Midland Branch of the Institution of Occupational Safety and Health (IOSH). Potential participants were initially contacted by telephone and all contacted agreed to participate. The profile of the group is summarised below and in Table 10-1.

Qualifications

- Nine participants had the NEBOSH Diploma in Occupational Safety and Health;
- One person had a BSc degree in Occupational Health and Safety.

Professional Bodies

- All were corporate members of the Institute of Occupational Safety and Health;
- Five were Registered Safety Practitioners (RSPs).

Experience

- All were working as safety practitioners with one person a full-time consultant;
- All had considerable experience in health and safety averaging 8 years.

10.2.2.3 Occupational health nurses

A typical group of experienced occupational health nurses was recruited for participation in the study. Volunteers included past graduates of the Occupational Health Nursing Postgraduate Diploma course at Wolverhampton University. A letter was sent to former students asking for volunteers as participants in the study (Appendix Eight, Section 14.8, page 381). Other occupational health nurse participants were identified through third party intermediaries. The profile of the group is summarised below and in Table 10-1.

Qualifications

- All were registered general nurses;
- All possessed the occupational health nursing diploma;
- Four had the NEBOSH Certificate in Occupational Safety and Health;

Professional Bodies

Eight were members of the Royal College of Nursing;

Experience

All were working as occupational health nurses;

All had considerable experience in occupational health nursing averaging eight years.

10.2.2.4 Occupational health physicians

A typical group of experienced occupational health physicians was recruited for the study. Personal/third party contacts and the membership list of the UK Society of Occupational Medicine (SOM) was used to identify possible participants. Contact was made with volunteers by telephone and via a letter distributed by the Society of Occupational Medicine (Appendix 14.8) and all individuals contacted agreed to participate. The profile of the group is summarised below and in Table 10-1.

Qualifications

- All were registered medical practitioners;
- Seven possessed the Associateship of the Faculty of Occupational Medicine;
- Two possessed a Diploma in Industrial Health;

Professional Bodies

- All were members of the Faculty of Occupational Medicine;

Experience

- All were working in occupational medicine although one person had recently retired;.
- All had considerable experience in occupational medicine averaging 14 years for the group as a whole.

10.2.2.5 Trainee health and safety inspectors

A typical group of trainee health and safety inspectors was recruited for participation in the study. Participants were recruited from a group undertaking the Aston University Postgraduate Diploma course in Occupational Health and Safety in 1993. Volunteers were randomly selected from the student group. The profile of the group is summarised below and in Table 10-1. The participants from this group took part in the exercise prior to their attendance on the occupational health module of the Diploma course. However, they had taken the first half of the risk management part of the course.

Qualifications

- All had graduate or graduate-level qualifications as a minimum in a range of disciplines;
- One had a Diploma in Environmental Protection;

Professional bodies

- None were members of professional bodies concerned with health and safety;

Experience

- All had spent at least one year working for the Health and Safety Executive in a general inspection role;
- One person had worked as a pollution control officer.

In Table 10-1 (below) the following abbreviations are used for the participant groups:

OH – occupational hygienists

SP – health and safety practitioners

OHN – occupational health nurses

OHP – occupational physicians

HSI – trainee health and safety inspectors.

Table 10-1 Participant Group Profiles

	Qualifications	*Experience*	*Years.*
OH1	BSc Occ Hyg; MSc H & S; MIOH	Industry/Enforcement authority	9
OH2	BSc Eng; MSc Occ Hyg; MIOH	Industry	12
OH3	BSc Chem; Dip Occ Hyg; MIOH	Industry/Consultancy	14
OH4	LRIC Chemistry; FIOH	Industry	25
OH5	BSc Eng; MSc Occ Hyg; FIOH	Industry/Educ./Consultancy	>20
OH6	GRSC Chemistry; Dip Occ Hyg; MIOH	Industry	19
OH7	BSc Biol; Dip Occ Hyg; NEBOSH Dip; FIOH	Enforcement authority/Industry	15
OH8	PhD Chemistry; Dip Occ Hyg; FIOH	Industry	>20
OH9	Dip Occ Hyg; MIOH	Industry	12
OH10	BSc Eng; MS Ind Hyg; FIOH	Education/Industry/Consultanc	>20
OH11	BSc Occ Hyg; MIOH	Consultancy	3
OH12	MSc Safety & Hyg; FIOH	Industry/Consultancy	13
SP1	NEBOSH DIP; BSc Biol MIOSH	Local authority/Env Health	4
SP2	NEBOSH DIP; RSP; MIOSH	Industry	12
SP3	NEBOSH DIP; BA; MIOSH	Industry	8
SP4	NEBOSH DIP; HND Eng; MIOSH	Industry	10
SP5	BSc H & S; MIOSH; RSP	Local authority/Consultancy	14
SP6	NEBOSH DIP; MIOSH; RSP	Local authority/Industry/NHS	10
SP7	NEBOSH DIP; HND Eng; MIOSH RSP	Local authority/Industry	7
SP8	NEBOSH DIP; BTEC MIOSH; RSP	Industry/Local authority	10
SP9	NEBOSH DIP; MIOSH	Industry	3
SP10	NEBOSH DIP; BSc Chem MIOSH	Industry	3
OHP1	MD; DIH; MFOM	Consultancy	12
OHP2	MB BS; MFOM	Industry/NHS/Consultancy	8
OHP3	MB BS; AFOM	Industry	14
OHP4	MB BS; DIH; FFOM	Industry	>20
OHP5	MB ChB; AFOM	Industry/Local authority	9
OHP6	MD; MFOM	Industry/Local authority/NHS	6
OHP7	MB ChB;	NHS/Industry	20
OHP8	MB ChB; DIH; FFOM	Industry/Enforcement authority	17
OHP9	MB BS; MFOM	Industry	1

Table 10.1 Participant Group Profiles (cont'd)

	Qualifications	*Experience*	*Years*
OHN1	RGN; OHNC	Industry	14
OHN2	RGN; OHNC	Local authority	5
OHN3	RGN; OHNC	Industry	7
OHN4	RGN; OHNC; NEBOSH Cert	Local authority	4
OHN5	RGN; OHNC; NEBOSH Cert	Local authority	3
OHN6	RGN; OHNC	Local authority	6
OHN7	RGN; OHNC; NEBOSH Cert	Industry	10
OHN8	RGN; OHNC	NHS/industry/Enforc. Auth.	20
OHN9	RGN; OHNC	Local authority/industry	10
OHN1	RGN; OHNC	Industry	14
HSI1	BSc Social and Economic History	Enforcement authority	1
HSI2	BA History; RGN	Enforcement authority	1
HSI3	BSc Agriculture	Enforcement authority	1
HSI4	BEng Electronics Engineering	Enforcement authority	1
HSI5	BEng Chemical Engineering	Enforcement authority	1
HSI6	BA Philosophy/Politics	Enforcement authority	1
HSI7	BSc Chem/Biol; Dip Env Protection	Env Health/Enforc. Authority	4
HSI8	BSc Physics; PhD Mechanics	Enforcement authority	1
HSI9	BSc Agricultural Chemistry	Enforcement authority	1
HSI10	BSc Pharmacology	Enforcement authority	1

10.2.3 EQUIPMENT USED AND DATA AVAILABLE

- Panasonic videotape player and television;
- Sony Dictaphone (Model TCM-38V) with remote microphone;
- Health and safety data sheet for resin (as supplied by manufacturer).

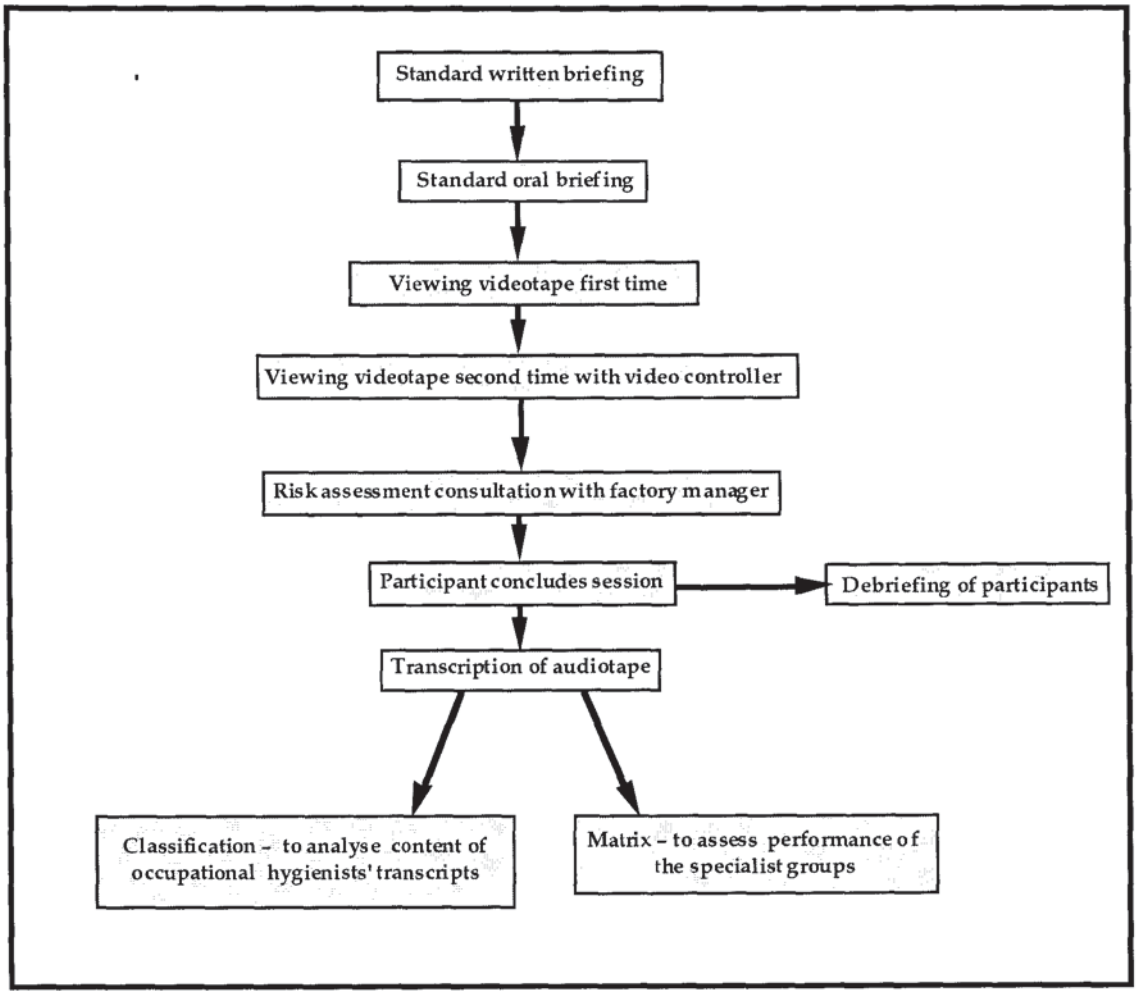
10.2.4 LOCATION

Consultations took place at the participant's place of work, home or Aston University (depending on the participant's preference).

10.2.5 PROCEDURE

This is outlined in the Figure below:

Figure 10.3 Study procedure



1. Participants were given a standard oral briefing on the overall aim and objectives of the exercise (Appendix Six, page 373). They were asked to carry out an assessment of health risks and to recommend necessary action. They were informed that the consultation was to be recorded on audio-tape to obtain a full account.

2. Participants were then asked to read through a standard briefing (as modified after the pilot Study). (Appendix Six).

3. At this stage they were not given any further information about the factory other than to be told that it was a 'moulding operation'. Where further

information was required, this was to be obtained from the interviewer role-playing the factory manager. They were asked to continue until they felt they had obtained enough information.

4. Participants were then asked further questions to confirm that they had understood the brief and what was required.
5. The videotape was then played once through and participants watched without interruption.
6. Participants were given the remote control and asked to watch the tape again at their own pace, and obtaining additional requisite information from the factory manager.
7. The consultation was terminated when participants decided that they had enough information to conclude their brief.
8. Each participant was allowed time (if required) to prepare a report for the interviewer. The length of time was determined by participants and was usually 10-15 minutes.
9. Participants gave an oral report on perceived health risks and recommendations for action. (Some included a brief written report although this was not specifically requested in the briefing.)
10. There was a short discussion about the factory and a debriefing for each participant. They were asked for comments on the consultation exercise.
11. Written transcripts were produced from the audio-tapes for later analysis.
12. The content of tape transcripts for the occupational hygienists was analysed for content and categorised using a classification designed for this purpose (Figure 10.4, below). This involved dissecting the whole transcript and placing fragments of text (questions, comments, recommendations) into appropriate categories for further examination. (Figure 10.5)
13. A matrix (based on HSRA Model B) was developed to enable evaluation of the performance of each participant and the five specialist groups in the exercise. An illustrative sample from this matrix is presented as Figure 10.6.

Figure 10.4 Classification used for transcript content analysis

1. BUILDING
2. MOULDING PROCESS
3. Preparation
4. Activating Resin
5. Cutting Glass Fibre (GF)
6. Laying-Up
7. Curing
8. Finishing
9. Repair
10. Chemical Hazards
11. General Workplace Hazards
12. Noise
13. Lighting
14. WORKFORCE
15. Health Effects
16. Pattern Of Work
17. Numbers
18. CURRENT CONTROL MEASURES
19. Ventilation
20. Personal protective equipment
21. Eye wash
22. Housekeeping
23. Storage & handling
24. Health surveillance
25. First aid
26. Risk assessment
27. Substance inventory
28. Hazard data sheets
29. Air monitoring
30. Training
31. Information
32. Spillage procedure
33. Waste disposal
34. Fire precautions
35. Welfare
36. Maintenance
37. HSE inspections
38. General management
39. Health and safety organisation
40. Workshop manager
41. Other controls
42. **Miscellaneous**
43. CONCLUSIONS
44. RECOMMENDATIONS
45. Elimination/substitution
46. Ventilation
47. Personal protective equipment
48. Eye wash
49. Housekeeping
50. Storage/handling
51. Health surveillance
52. First-aid
53. Risk assessment

cont'd

Figure 10-4 (cont'd)

RECOMMENDATIONS (cont'd)
54. Substance inventory
55. Hazard data sheets
56. Air monitoring
57. Training
58. Information
59. Spillage procedure
60. Waste disposal
61. Fire precautions
62. Welfare
63. Maintenance
64. General management
65. Health and safety organisation
66. Workshop manager
67. Miscellaneous

10.2.6 ANALYSIS

Each interview transcript was scrutinised and questions, statements, and comments were assigned to one or more categories. Some fragments fitted into more than one category and in this case a copy was placed in each category. For example, the following comment:

"I recommend that everyone has some training in fire precautions."

could be classified as a recommendation under training and also under fire precautions and a copy of this recommendation was included in both categories. The size of the fragments varied from simply a short statement or question to a whole paragraph. A further example of categorisation is given below in Figure 10.5.

Figure 10.5 Sample from classification (Participant – OH1)

5.0 CUTTING Glass Fibre (GF)
What is he doing here? [cutting GF] Does he do that all day? [cutting GF] So they switch jobs and take it in turns? But on a particular day one person may cut it up for everybody else? But someone would not be doing that all day? [cutting GF]
6.0 LAYING-UP
So you mix them together and then what? [application of base resin] Is that the same type of thing then? [broadly - but some differences] In what way do they differ? Do you paint that on the mould by hand? OK you put that on and then you paint on your first coat of base resin? Can you describe how you would apply that? [the mould resin] How many layers would you do like this? So you would do one layer and immediately start applying the next or would you wait? And how long does all this take? How long do you think it would take to apply the 3 layers of mould resin and fibre glass? Does that include the waiting time? When you have got the mould resin applied the top surface is still pretty rough? Two blokes working on one mould? Have you got any gloves?
7.0 CURING
What happens when it cures? Does it get warm when it is curing? Or does it just sit there and gradually go hard?
8.0 FINISHING
When we have got the three layers on what happens next? So in the process we have got these three layers of resin and fibre glass on, so what happens next? Is there anything else done to it? Which surface are we talking about here - the surface that has been in contact with the mould or the top surface? Have we taken it off the mould yet? Is it easy to get it off the mould or do you have to have to do anything to it? So it is taken off the mould and taken to another workarea? Using what [tool] did you say? A power tool? Like an orbital sander - something like that? Is that electric or compressed air? Can I see that?

10.2.6.1 Assessing the performance of the specialist groups using a matrix

A matrix with 137 defined categories was used to assess the performance of the different specialist groups in the exercise. Where a transcript indicated that the attribute had been satisfied, then the participant was awarded points according to a pre-defined scoring system. Scores in column two for the different attributes were allocated by the author. An illustrative sample from the matrix is given below (Figure 10.6) with the full version given as Table 11-23 (Insert).

The matrix was structured broadly based on HSRA Model B described in Chapter Nine and applied to the GRP process below. The matrix performance scores of participants from the specialist groups are presented and discussed in Chapter Eleven (Section 11.4). Findings are presented in Chapter Eleven, **Table 11-1** to **Table 11-22**.

Figure 10.6 Illustrative sample from the performance matrix

CATEGORIES		Health and safety inspectors										
		hsi1	hsi2	hsi3	hsi4	hsi5	hsi6	hsi7	hsi8	hsi9	hsi10	
Define system or process												
identifies size and nature of co.	1											
identifies how long the factory in operation	1	1	1		1							3
identifies number of employees	1			1	1			1				3
identifies number in workarea	1		1					1			1	3
identifies product	1	1		1	1	1	1	1	1	1	1	9
Total A	5	2	2	2	3	1	1	3	1	1	2	
Process elicitation/task id												
identifies mould preparation	2	2	2			2	2	2	2	2	2	16
identifies drum storage of resin	2	2	2	2	2	2	2	2	2	2	2	20
identifies resin activation	3	3	3		3		3	3		3		18
identifies cutting GF sheets	2	2	2			2	2	2	2	2	2	16
identifies laying-up	3	3				3	3	3		3	3	18
identifies curing process	2		2					2				4
identifies finishing	3	3	3					3	3			12
identifies mould repair	2	2	2			2	2	2	2	2	2	16
Total B	19	17	16	2	5	11	14	19	11	14	11	
Task characterisation												
mould preparation task												
identifies polishing	1	1	1			1	1	1	1	1	1	8
identifies silicone wax	1		1				1	1		1	1	5
resin storage task												
identifies nature of resin	2							2	2	2	2	8
identifies styrene consumption	3	3			3			3		3		0
resin activation task												
identifies mixing method	2				2			2		2		0
identifies nature of catalyst	2	2	2		2		2	2		2	2	14
identifies use of other solvents	1		1			1		1		1	1	5
laying-up task												
identifies use resin and GF	2	2	2		2	2	2	2		2	2	16
identifies application of layers	2					2		2				4
finishing task												
identifies separate area	1	1										1
identifies power sander	2	2	2									4
repair task												
identifies substances used in repair	1	1	1			1	1	1	1	1	1	8
identifies task times	4	4				4		4				12
Total C	24	16	10	0	9	11	7	21	4	15	10	
Hazard identification and exposure assessment												
identifies general dust hazard	2	2					2		2	2		8
identifies smell	2	2	2	2		2	2	2	2	2	2	18
identifies worker health effects/complaints	3	3	3	3		3	3	3	3	3	3	27
identifies drum labelling	2					2						2
identifies solvent vapour hazard (styrene)	3	3	3	3	3	3	3	3	3	3	3	30
identifies resin skin contact hazard (styrene	3	3						3	3	3	3	15
identifies GF skin contact hazard	3			3		3	3		3	3		0
identifies GF dust hazard	2	2					2			2		6
identifies general ingestion hazard	1										1	
identifies previous air monitoring data	2			2					2	2	2	8

10.2.7 CASE STUDY - RISK ASSESSMENT SOLUTION USING HSRA MODEL B

The HSRA Model B is applied to the GRP factory to produce an 'ideal' solution to the problem. Transcripts and participant performance are evaluated using this solution (Chapter Eleven).

This model is used to illustrate a comprehensive approach to the risk assessment exercise. This is in excess of what could reasonably be expected from participants bearing in mind the constraints of the experimental method which are discussed further in Chapter Twelve. Nevertheless, it is believed that this idealised view does provide a useful benchmark for interpretation and evaluation of transcripts.

This solution is based on the author's general analysis of the situation at the factory resulting from:

- visiting and carrying out styrene exposure monitoring in the actual factory;
- eliciting information directly from management and workers at the factory;
- studying/viewing the videotape; hazard data sheets and associated materials over a period of time;
- information gained from wider aspects of this research and the author's personal experience.

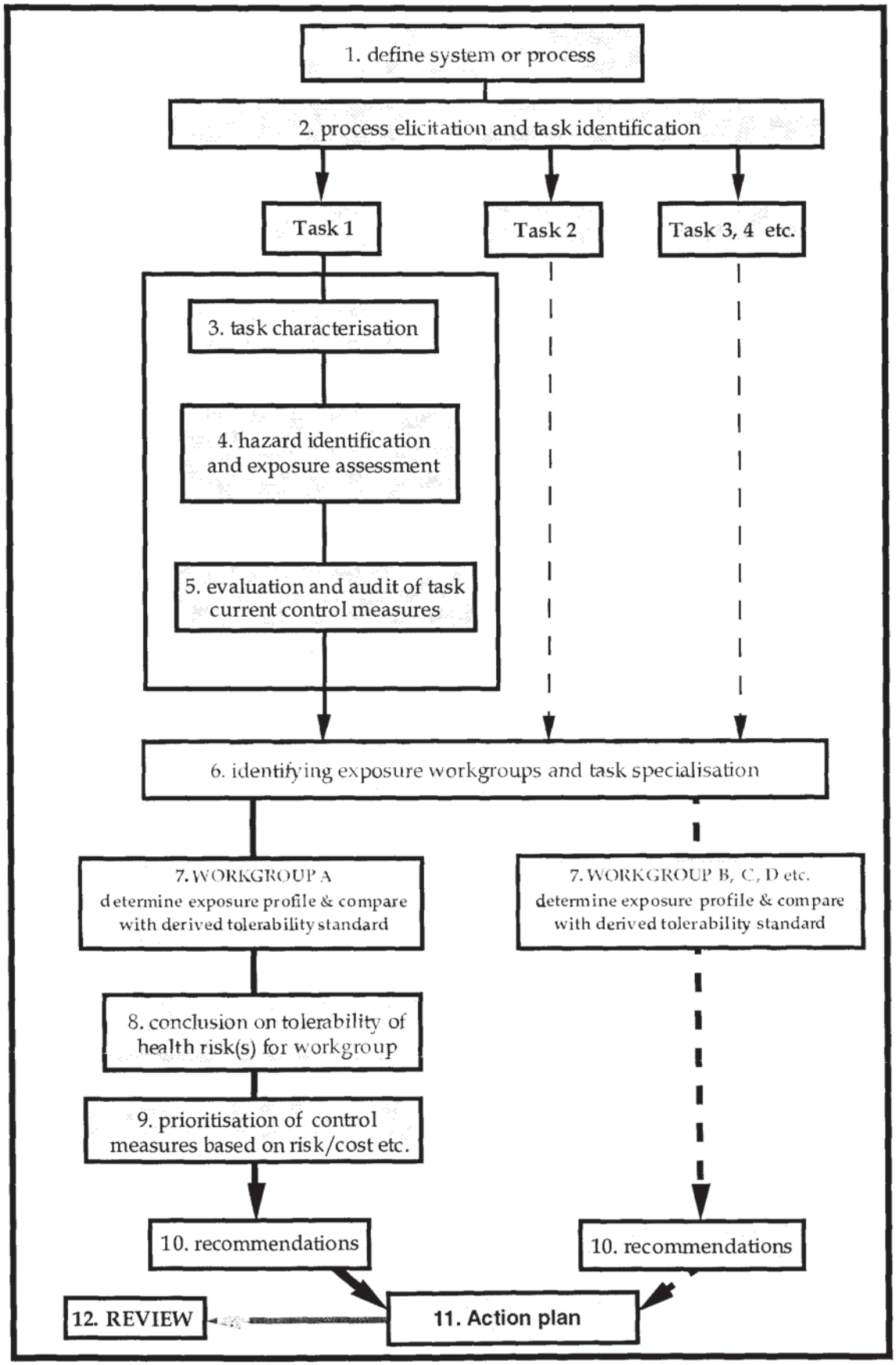
In contrast, available information sources for study participants were:

- visual information on the factory and process tasks from the videotape (six minutes duration);
- oral information elicited from the 'factory manager' during the consultation;
- written information from the single resin hazard data sheet (which had to be elicited from the manager);

their own personal training and experience.

The general HSRA Model B is outlined below in Figure 10.7.

Figure 10.7 HSRA Model B



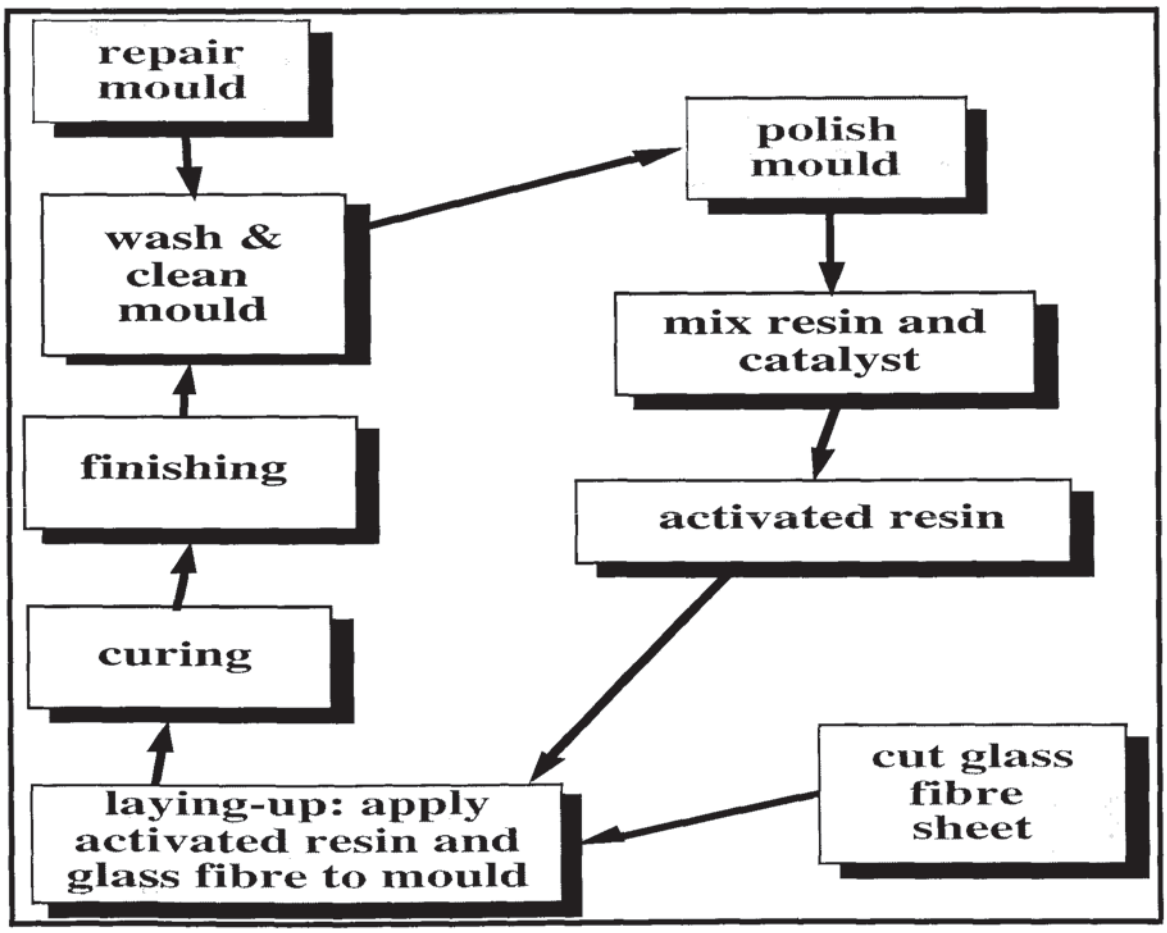
10.2.7.1 Define system or process (stage 1)

The process under consideration is the moulding process carried out at the factory featured in the videotape. The participant is requested in the briefing to carry out a "health risk assessment and make recommendations for action" at this factory.

10.2.7.2 Process elicitation and task identification (stage 2)

The risk assessor initially identifies the relevant stages and tasks in the production process, which then allows activity or task-driven risk assessment to proceed. The process cycle below represents the central production activity at the factory (Figure 10.8). It is this that participants must elicit prior to risk assessment. Some tasks are visually highlighted in the videotape whilst others must be identified by questioning the factory manager. Tasks with darkly shaded boxes are seen in the videotape whilst the others are not featured.

Figure 10.8 Basic steps in the factory GRP process



10.2.7.3 Task characterisation (stage 3)

Once a process stage or task has been identified, then other information is needed:

- the hazardous substances and preparations used (Table 10-2);
- the rate of consumption of substances (principally styrene-based polyester resins – up to one drum (45 gallon) per week);
- process conditions – activities are carried out at ambient temperatures, although in the Winter the temperature cannot be allowed to fall too low or curing will proceed only very slowly;
- machinery and equipment used – resins and paints are brushed on manually (there is no spraying), small hand tools to ensure consolidation of the GRP moulded product; a stanley knife is used to cut the glass fibre sheet, a power sander is used in finishing, a forklift truck transports resin drums and pallets of glass fibre sheet in and out of the factory;
- task duration and frequency – task times for regular tasks in the moulding process (and also occasional tasks) are given in Table 10-3. The moulding cycle is continuous full-time work. 'Laying-up' was the longest duration task in the moulding cycle. This involved laying pieces of cut glass fibre sheet on to the moulding and soaking this with resin using a paint brush. At this stage, 'rolling and dabbing' was needed to ensure that the surface is uniform and any air bubbles in the moulding were removed. Questions concerning task duration (and frequency) are essential in building up hazard exposure profiles for task operators and their workgroups.

Table 10-2 GRP process – substances used (or arising from)

TASK	SUBSTANCES
mould preparation	silicone wax – mould release agent
resin activation	styrene based polyester resin – organic peroxide catalyst
cutting glass fibre strips	glass fibre
laying-up	styrene based polyester resin & glass fibre sheet
finishing	GRP moulding dust
mould pattern repair	'two-pack' filler (epoxy resin)
various cleaning tasks	acetone solvent
storage/handling	styrene based polyester resin, catalyst, pallets of GF sheet
various painting tasks	solvent-based paints

Table 10-3 GRP process task times

1	Mould preparation	45 minutes
2	Resin activation	15 minutes
3	Cutting glass fibre	15 minutes
4	Laying-up/consolidation (3 layers with 30 minutes curing between layers)	4 hours
5	Final curing of mould	4 hours
6.	Finishing	1 hour
6	Cleaning brushes/pots	15 minutes
7	Repair of moulds	2 hours

10.2.7.4 Hazard identification and exposure assessment (stage 4)

This is considering the three principal routes of exposure to toxic substance hazards ie, inhalation, ingestion and skin contact/absorption and identifying if any of these routes is likely to be important for the process tasks in question. At this point[8] the assessor also considers foreseeable task failures and their implications for hazard generation and consequent risk.

First, further information about the GRP process and tasks needs to be obtained by observing the work (via the videotape) and asking the questions. The following information is needed:

- task/operator characteristics - several tasks are seen where workers have their breathing zone close to the application point for substances - for example, mould repair, polishing and laying up. In the latter a large surface area has resin brush painted over it;
- inhalation hazards - there is a smell in the work area (in the exercise this is found by questioning whilst in the real factory there was a powerful odour), a dust aerosol is generated particularly in the finishing task and to a lesser extent during cutting of the GF sheet; volatile substances are used -

[8] This stage can also be the starting point for integrated risk assessment involving the identification of other (non-substance) health hazards. With the GRP factory this could include other health hazards and safety hazards, for example, fire.

styrene solvent, acetone, paint solvents including xylene; styrene resin is spread over the large surface area of the moulding; the operator carries this out in close proximity to the vapour emitting surface (laying-up);

- skin contact hazards – there is contact between substances and unprotected skin in the observed laying -up task (styrene resin and glass fibre sheet), the GF cutting task; the polishing task (silicone wax) and also in the unseen resin activation and finishing tasks;

- ingestion hazards – in the videotape a cup of tea is brought into the work area indicating that food and drink is consumed in this area; welfare provision at the factory – ie, the facilities for eating and drinking/washing and changing are very limited and basic;

- control and protective measures – few such measures can be seen at the factory; there is no indication of any mechanical ventilation systems; a few workers bring in their own personal protection equipment (ie, gloves and overalls) but management does not provide any special PPE; the factory work area can been seen to be very cluttered and untidy.

Table 10-4 (below) gives important information that can be obtained when watching the videotape. (With this study method there are difficulties in monitoring participants' gathering of data by visual task assessment, since they may observe and mentally note aspects without any verbalisation. This is discussed further in Chapter Twelve.)

Since several important moulding cycle tasks are not featured in the videotape (and even if the existence of a task is identified, visual assessment is obviously not possible) then such information must, as far as possible, be elicited by questioning the manager. Part of the skill of an expert is to be aware that relevant tasks may not be happening during an inspection or visit. In a real factory, a visitor may ask to see a particular task having discovered its existence, although, even on such a visit, some tasks may only be described verbally.

Key tasks and process stages *not* illustrated in the tape were:

- some aspects of mould pattern preparation;
- mould resin dispensing and activation - this involved mixing resin with a dangerous and toxic organic peroxide solution;
- curing stages;
- finishing - this task was carried out in an adjoining workshop and this task generated large quantities of airborne dust from a sanding process.

Normally, on a visit to a workplace, information on the nature of processes/tasks can be obtained by questioning the manager and 'task operator' (ie, the person who actually carries out the activity). Unfortunately, in this scenario at the GRP factory, only the factory manager is available for interview. Nevertheless, the following type of information can be elicited:

- manufacturer/supplier's product hazard data sheets - only one HDS relating to the styrene-based polyester resins has been obtained by the manager (this gives good quality information on physical chemical properties, health and safety hazards, first aid, fire precautions) (Appendix Four, page 365). This was available for participants to consult on request once they had determined its existence from the factory manager;
- health effects/complaints in exposed workers - according to the manager (accurately reported) there was no indication of adverse health effects in, or complaints from, the workforce, but there was an acknowledged high turnover in the workforce. (The workers themselves would probably have reported otherwise regarding health effects and complaints, principally headaches and skin irritation, but on the whole they were pleased that resin was not sprayed, where conditions were perceived to be worse);
- foreseeable task failures - evidence of minor leakages and spillage of resin around the drums can be seen in the videotape. A large scale spillage from the rupture of a resin drum is a possibility at the factory. This would result in the highly dangerous release of large quantities of a highly flammable liquid;

- indication of other (non-substance) health hazards.
  - *lighting* (poor and inadequate in moulding area)
  - *noise* (use of power sander in finishing area)
  - *manual handling* (moving empty resin drums, boxes of GF sheet, finished mouldings)
  - *safety hazards* (although these were not striclty within the remit of the briefing, they include fire, tripping, electrical and fork-lift truck hazards).

Table 10-4 GRP process – visual assessment and principal tasks

TASK	VISUAL ASSESSMENT
Mould pattern washing and cleaning	• not seen in the videotape
Polishing	identifying skin contact • person seen with hands in contact with rag [silicone polish] –no visible hand protection
Resin activation	• not seen in the videotape
Glass fibre cutting	identifying skin contact • people are seen with their hands in contact with glass fibre; no hand protection is visible • two workers carrying out this task are wearing overalls
Laying-up	identifying inhalation • physical dimensions of emitting source(s) – the volatile resin is seen to be painted over a relatively large surface area • proximity of exposed person – the breathing zone of the exposed person (nose and mouth) is seen to be in intimate contact with the moulding surface • people are seen painting on resin – there is no respiratory protection visible • there is no visible sign of any dilution or mechanical ventilation identifying skin contact potential • people are seen with their hands in contact with the resin and glass fibre – no hand protection is visible • some people are wearing overalls and others are not • one person has his wrists taped up
Finishing	• not seen in the video
Repair	identifying inhalation and skin contact potential • person working with face and nose in close proximity to 'two-pack' filler with no visible hand or face protective equipment
Drum storage	identifying fire and explosion hazards • resin/catalyst drum storage is seen to be excessive and poorly sited with obvious visible uncleared spillages of resin • poor labelling of drums is also evident – lack of hazard warning signs
Housekeeping	• workplace is seen to be badly organised and untidy

10.2.7.4.1 Summary of hazard identification and exposure assessment data[9]

Resin activation

There is inhalation exposure to styrene vapour and potential for skin contact with the liquid resin during this relatively short duration task.

GF cutting

Unprotected skin contact with the GF is evident during the fibre sheet cutting task, although this takes up only a short time in the overall moulding cycle.

Laying-up

Various factors, noted above, enhance inhalation exposure to styrene vapour in this task. This is the longest duration task in the production cycle and consequently there is likelihood a high cumulative inhalation exposure over much of the working day.

Skin contact hazards are important since direct contact is seen between unprotected skin and both styrene-containing resin and glass fibre sheet again over a significant period of time.

Curing

Curing results in inhalation exposure to styrene vapour. Curing takes place at various points in the work area for long periods of time during the during the day. This creates a background exposure for all working in the moulding area.

Finishing

This sanding operation creates large quantities of mixed resin/glass fibre dust. One operator carries out this task on a full-time basis and this represents an important inhalation hazard. The finisher was wears respiratory protective equipment, which will be evaluated below.

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[9] In the experimental consultation no air monitoring data was available for the risk assessor. Participants had to make an estimate based upon their observations and discussion with the manager. In fact, limited personal monitoring of moulders for styrene exposure, indicated that further precautions were needed at the factory.

Mould pattern repair operation

The mould pattern repair task uses toxic substances which may be inhalation and skin contact hazards. This task is only carried out intermittently over short periods of time.

10.2.7.5 Evaluation and audit of current control measures (stage five)

Following estimation of exposure for process tasks, the assessor now takes account of the presence and effectiveness existing control measures before coming to a conclusion on residual risk. Ideally, the assessor should ascertain the following information in the case of each control measure applied in the case of each task:

- is the control measure currently applied? (ie, does it exist?);
- is the control measure theoretically adequate?
- is the control measure adequately used?
- is the control measure adequately maintained? (*reviewed* if the measure is a procedure);
- are adequate records are kept relating to the control measure?

At the GRP factory, the following tasks had an almost universal lack of applied control measures:

- laying-up;
- finishing;
- GF cutting;
- curing and resin activation;
- pattern repair operation.

This lack of controls included general and local exhaust ventilation as well as the failure to utilise personal protective equipment. It is necessary to distinguish whether personal protective equipment (PPE) is not provided by management (ie, the control measure does not exist) and whether equipment is supplied but not accepted and worn by the operators. If the latter option were the case the assessor would want to know why the usage of the PPE was not adequate. In fact at this factory PPE as a control measure does not exist and

with the exception of the finisher, the company did not issue any personal protection equipment.

Ventilation control

Some control measures such as general ventilation will apply to more than one task. Once the control has been evaluated for one task the results can be extrapolated to the other tasks. Questions on ventilation control needed to address the following:

Moulding area - identifying general ventilation and local exhaust systems; (in this area the only ventilation was the main door which was kept closed in Winter); this as a source of general ventilation was not theoretically adequate.

Finishing shop - identifying general ventilation and local exhaust systems; (in this area ventilation was provided by an open door and window and a small window-mounted Expelair fan); this as a source of general ventilation was poor.

General controls - health and safety management

The company had no health and safety policy and little health and safety organisation. Furthermore, neither management nor workforce had had any special training in health and safety. The workforce had very little information on the substances they were working with, except that they constituted a fire hazard and they should not smoke in the work areas.

10.2.7.6 Identifying workgroups and task specialisation (stage six)

Two exposure groups can be identified at the GRP factory ie, the 'moulder' and the 'finisher' workgroups. The moulders carried out the following tasks in the moulding cycle - mould pattern preparation; activation of the resins; cutting GF sheet; laying-up resin and GF; removal of the moulded product from the pattern and transportation of the moulding to the finishing shop (after final curing) . The finisher specialised in the sanding (smoothing) of the mouldings and this was his sole task.

Workgroup exposures

Moulders were exposed to all substances used in the moulding process in the main work area. The major exposure of the finisher was to dust from the moulded product (resin/GF) which he created during 'sanding down'. The finisher worked alone in a segregated workshop. This is key information when trying to estimate the daily substance exposure profile of each workgroup.

10.2.7.7 Comparing the estimated exposure profile with derived tolerability standard (Stage seven)

For each workgroup, the next stage is to compare estimated residual exposure (ie, taking account of any controls) with a tolerability standard for health risk. This involves considering hours of work, the time a typical moulder and finisher spend on their different tasks. This should take into account 'worst case' exposure conditions (in this factory - maximum production on a cold day).

For a typical moulder and finisher, the assessor has to estimate (and possibly measure with technical equipment) exposure to substance hazards during each task. Evaluating inhalation exposure is the major challenge, since any skin contact and ingestion exposure would normally be unacceptable.

Having estimated the exposure profile of each workgroup the assessor can interpret this using the following proposed indicators of 'unacceptable' exposure shown below in Table 10-5 (as reproduced from Chapter Nine):

Table 10-5 Indicators of 'unacceptable' exposure to substances

- non-compliance with MEL limits - moulders and styrene vapour
- non-compliance with OES limits (in excess of c.25%)
- non-compliance with the HSE dust standard (in excess of c.25%) - finisher exposure
- evidence of acute health effects in workers connected with exposure
- consistent complaints from workers of associated odour or discomfort
- evidence of sensitisation particularly in the respiratory system or skin
- significant potential for ingestion of substances
- significant potential for eye contact with substances - moulders and finisher
- significant skin contact with toxic substances - moulders (styrene resin and GF sheet)
- regular unprotected exposure for long periods of time

Moulder workgroup

1. Exposure to styrene vapour is in excess of the MEL adopted for styrene – as eight-hour and fifteen minute time-weighted average values.
2. There is significant skin contact with styrene-based resin and glass fibre particles which represent an intolerable health risk.

Finisher workgroup[10]

1. Although there is significant exposure to dust from the sanding operation, because of the effective respiratory protective equipment provided, the inhalation health risk is controlled to a tolerable level.

10.2.7.8 Conclusion on tolerability of health risk(s) for each workgroup (Stage eight)

The assessor should reach a conclusion on health risk for each workgroup. For an individual workgroup group, some tasks will have insignificant health risks, but others may present significant (uncontrolled) risks and thus action is needed.

Intermediate conclusions on risks to health:

These conclusion options will now be applied in the GRP factory:

1. risks to health unlikely;
2. risks significant - all adequate precautions in force;
3. risks significant - further precautions need to be applied;
4. uncertain about risks to health - further information required;
5. uncertain about precautions necessary - further information required.

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[10] Furthermore, in this case there is also exposure to excessive noise and the second action level of the Noise at Work Regulations 1989 is being exceeded.

Moulder workgroup

Health risks significant – further precautions need to be applied:

- inhalation exposure to styrene vapour – key tasks for further precautions are laying-up, curing and resin activation;
- skin contact with styrene-based resin – key tasks for further precautions are laying-up and resin activation;
- skin contact with glass fibre sheet – key tasks for further precautions are cutting GF sheet and laying-up;
- inhalation exposure to glass fibre particles – key tasks for further precautions are cutting glass fibre.

Finisher workgroup

Health risks are significant – all adequate precautions in force.[11]

- this could be provisionally applied to the finisher workgroup regarding toxic substance exposure. However, the assessor may well want to look into arrangements further for maintaining the effectiveness of the RPE used in this work area, given the apparent culture of this factory.
- the risk of eye damage from the sanding task is also significant although adequate precautions are in force since eye protection is afforded by the respiratory protective device.

All workgroups

Fire risk is significant – further precautions need to be applied.

- Key task for further precautions is storage of large amounts of resin in main work area in drums.

[11] However, exposure to a noise hazard arising from the sanding operation represents a significant risk where further precautions are required.

10.2.7.9 Prioritisation of tasks for control measures based on perceived risk (Stage nine)

For each workgroup the assessor ranks tasks and control measures:

Moulder workgroup

1. Key task for the moulders is laying-up, which requires control of styrene vapour inhalation and control of skin contact with both styrene-based resin and glass fibre.
2. GF cutting task requires control of skin contact with glass fibre.
3. Final curing stage needs segregation.
4. Better housekeeping in the main moulding area is needed.

Finisher workgroup

At this point no further control measures are necessary for the finishing operator as regards toxic substance exposure. However, protective measures are required to reduce noise exposure.

All workgroups

Control needs to be applied to current resin storage practice to reduce the fire risk.

General control measures

Some general control measures are needed for the whole workforce. A strategy for health and safety needs to be developed at the factory. This includes the production of a safety policy and plan for implementation. The workforce require instruction and training, which should include information on the hazards of the substances they are working with and the preventive measures which are needed.

10.2.7.10 Recommendations for action (Stage ten)

It useful to divide recommended actions for each workgroup into short-term and medium/long-term.

Moulder workgroup

Short-term measures

1. Provision of respiratory protection for moulders to wear during laying-up.
2. Carrying out air monitoring to measure personal exposures to styrene vapour.
3. Provision of suitable protective clothing during moulding work.
4. Provision of suitable protective gloves during moulding, particularly during laying-up and cutting glass fibre sheet.
5. Provision of arrangements to maintain the effectiveness of the above measures.
6. Provision of information, instruction and training on health and safety matters.

Medium/long-term measures

1. Investigate the feasibility of installing improved ventilation systems considering both dilution ventilation and local exhaust ventilation systems.
2. Investigate the feasibility of segregating the final curing stage of the process away from the main workarea.

Finisher workgroup

Short-term measures

1. Provision of hearing protectors (plugs) for use during sanding.

All workgroups

Short-term measures

1. Remove resin drums from the main work area to designated storage site.
2. Produce a health and safety policy and an organisational plan for implementing it for the company.
3. Have appropriate health and safety training for both management and workforce.

10.2.7.11 Action plan (Stage eleven)

This requires the integration of the measures required for the different tasks and workgroups into a single plan of action.

It would be inappropriate to give management a long 'shopping list' of discrete actions to comply with legislation and deal with acute problems. Such a list would not improve the attitude of management and once complied with, health and safety would probably be deemed to have been 'done'. Some structured strategic response is needed from management with suitable planning and allocation of resources. The need is to develop some basic health and safety (and other) organisation/systems within the company. A recommendation for the preparation of a health and safety policy and management training would be a reasonable step in the right direction at this stage.

Summary of final plan

Thus the final action plan should contain recommendations to:

1. As the major priority, remove the stored drums of resins to a suitable secure storage area.
2. Control health risks to the moulders specified above.
3. Control noise health risk to finisher.
4. Produce a company health and safety policy and organisational plan.
5. Have appropriate health and safety training for both management and workforce.

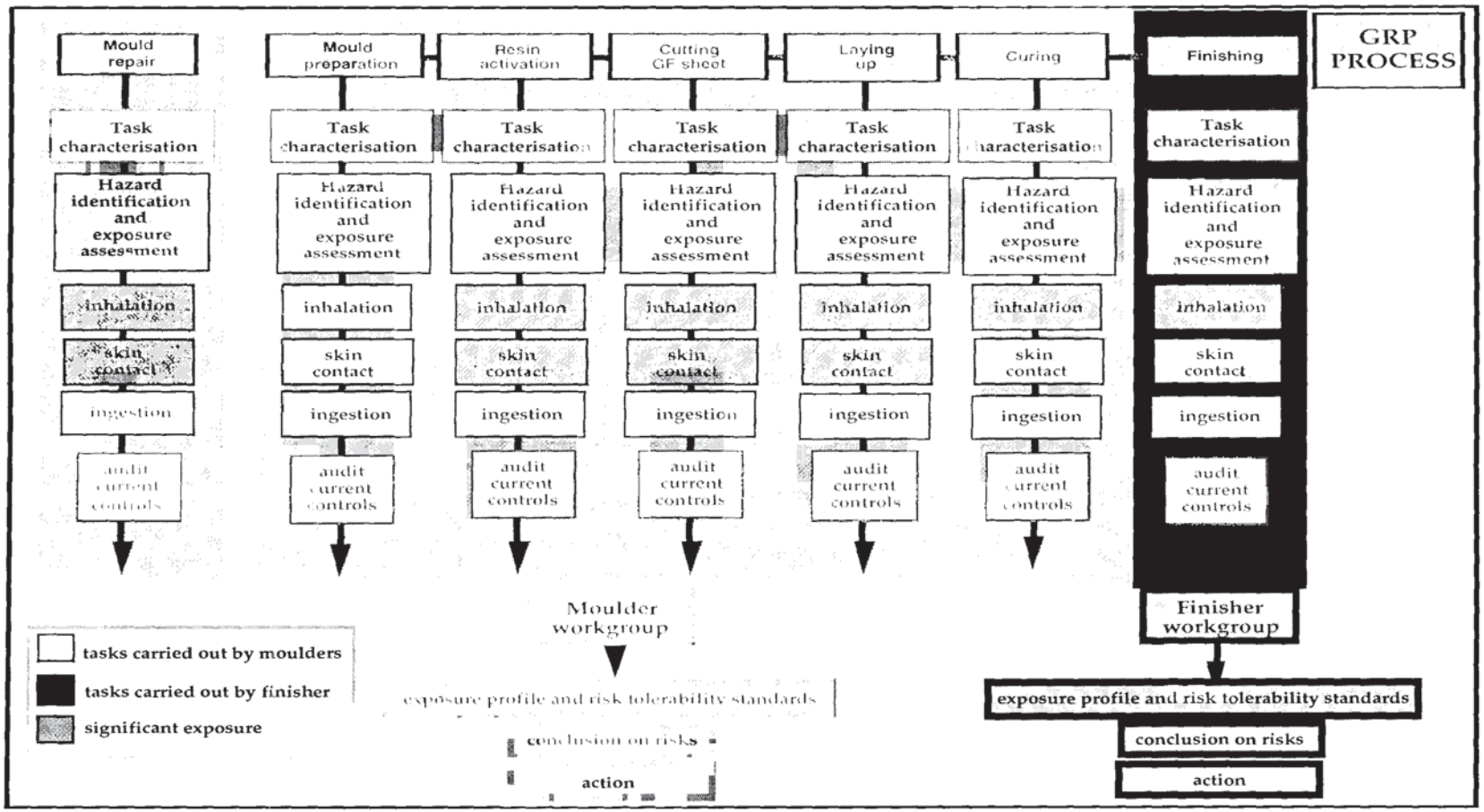
10.2.7.12 Review (Stage Twelve)

A system is needed for reviewing and auditing this whole risk assessment and management process.

10.2.7.13 Summary

The application of HSRA Model B to the GRP factory is summarised in Figure 10.9 below.

Figure 10.9 HSRA Model B applied to GRP process



11.

Knowledge elicitation: risk assessment videotape case-study – findings

11.1 INTRODUCTION

This Chapter presents and discusses the findings of the knowledge elicitation exercise. Where appropriate, findings are discussed with reference to the derived HSRA Model B (first described in Chapter Nine) as applied in the to the GRP factory in Chapter Ten (as an 'ideal' answer to the risk assessment exercise).

One objective of this exercise was to validate the videotape method as a useful approach to knowledge elicitation and methodological aspects are discussed in Chapter Twelve below.

A second objective was to investigate and characterise the approach of the occupational hygienist to HSRA and the final objective of this study was to look for commonalties and differences between participants, both within and between the defined study groups. As occupational hygiene has been proposed as the key centre of expertise in hazardous substance risk assessment, it seems reasonable to consider the approach of the occupational hygienists' group first and in detail (Section 11.3). This section demonstrates a wide variation in performance within this group with two participants performing poorly in the exercise. This is then followed by a comparison of performance in the exercise, of all participant groups as analysed using a purpose-designed matrix (Sections 11.4 and 11.5).

To summarise, this Chapter is divided into the following sections:

1. A brief review and general comments for all participant groups (Section 11.2).
2. Tabulation of consultation transcript data from the occupational hygienist participant group (Tables 11-1 to 11-22). These are set out in terms of the HSRA Model B with accompanying discussion (Section 11.3).
3. Performance scores for the five participant groups in the HSRA exercise are discussed in the text and represented graphically in Figures 11-1 to 11-23. The HSRA Model B is used to structure the matrix used for assessing performance of each group (Section 11.4).
4. A comparison of the five specialist groups in the risk assessment exercise using selected categories from the matrix (Section 11.5).

11.2 GENERAL COMMENTS - ALL GROUPS

All but one of the participants entered into the spirit of the role-play exercise. They commented that they found the exercise enjoyable, interesting and useful. Further, they made suggestions as to how the videotape technique could be applied further. The 'exception' (an occupational hygienist) prefaced most of the interaction with the factory manager with: "I would have asked ..." This person would not seriously enter into the role-play and was clearly in a hurry to complete the consultation as quickly as possible. Several other participants found the exercise quite stressful, partly because of the use of an audio-tape recorder. To some extent, the structure of the consultation resulted in a perceived (albeit unintended) challenge to their professional credibility and competence. Poor sound quality impaired the transcription of some tapes.

11.3 TRANSCRIPT ANALYSIS FOR THE OCCUPATIONAL HYGIENIST GROUP

There was substantial variation in the performance and approach of the individuals within this group. Results are presented in Tables 11-1 to 11-22. The following list summarises the content of each Table in terms of the logic of the HSRA Model B above.

HSRA Model B Stage 2

Table 11-1 Process elicitation and task identification (mould preparation)
Table 11-2 Process elicitation and task identification (resin activation)
Table 11-3 Process elicitation and task identification (laying-up)
Table 11-4 Process elicitation and task identification (finishing)
Table 11-5 Process elicitation and task identification (mould repair)

HSRA Model B Stage 3

Table 11-6 Task characterisation (laying-up resin and glass fibre)
Table 11-7 Task characterisation (duration)

HSRA Model B Stage 4

Table 11-8 Hazard identification and exposure assessment (health effects)
Table 11-9 Hazard identification and exposure assessment (hazard data)

HSRA Model B Stage 5

Table 11-10 Auditing current controls (ventilation)
Table 11-11 Auditing current controls (personal protective equipment)
Table 11-12 Auditing current controls (air monitoring)
Table 11-13 Auditing current controls (health surveillance)
Table 11-14 Auditing current controls (information and training)

HSRA Model B Stage 6

Table 11-15 Identifying workgroups and task specialisation

HSRA Model B Stage 7

Table 11-16 Comparing exposure profiles with tolerability standards

HSRA Model B Stage 10

Table 11-17 Recommendations (substance hazard data)

Table 11-18 Recommendations (personal protective equipment)

Table 11-19 Recommendations (air monitoring)

Table 11-20 Recommendations (health surveillance)

Table 11-21 Recommendations (information and training)

Table 11-22 Recommendations (ventilation)

Key to Tables and Figures

OH	occupational hygienists;
OHN	occupational health nurses;
OHP	occupational health physicians;
SP	safety practitioners;
HSI	trainee health and safety inspectors;
square bracket [ ]	indicate the author's insertions;
round bracket ( )	abbreviating the original transcript;
'no comment'	this term is used where nothing from a transcript could be classified in the particular category.

(Where brief, direct comments of participants have been quoted. However, where these were too long, the original transcripts have been paraphrased.)

The transcripts, of course, are the essential basis for ensuring that the questions/comments of participants relate to the issue identified. In each case this can be established from the manager's response. Comments are given in support of each Table only where necessary, otherwise, Tables are self-explanatory.

11.3.1 DEFINE SYSTEM OR PROCESS (STAGE 1)

To a large extent the system or process is defined for participants in the oral and written briefings. An assessment of health risks and recommendations for action were requested at the 'moulding factory'. Many participants asked if comments/questions/recommendations for action on 'safety' issues would be appropriate. (They were told these would be appropriate bearing in mind the requested emphasis on health risk assessment apparent in the exercise briefing.)

11.3.2 PROCESS ELICITATION AND TASK IDENTIFICATION (STAGE 2)

Transcript data relating to process elicitation and task identification (from the occupational hygienist participants) are summarised in Tables 11-1–11-5 below. Often, at the beginning of the consultation, general questions were asked on process elicitation:

> "Could you briefly run me through the process that is being carried out there?" (OH6)
>
> "Can you tell me what the people are actually doing?" (OH4)

To these open-ended questions the 'manager' consistently responded with a short descriptive statement: "Laying up some glass fibre with resin." This was similar to the real factory manager's initial response to this question. It was then for participants to use their skills to identify and obtain further information on the relevant process tasks. To elicit a full task breakdown for this particular GRP process, required a systematic questioning approach, single-mindedness and persistence. In a real factory visit the assessor would most likely meet more process jargon and technical detail than was supplied by this particular (surrogate) manager. (In a more naturalistic experimental set-up, the actual factory manager himself would have played this role in providing information with the video-tape, but this would also have had some disadvantages as is discussed in Chapter Twelve below.)

11.3.2.1 Common questions

From analysis of transcripts, it was observed that there were common questions likely to be asked by virtually everyone. This was the case with tasks given prominence in the video-tape (mould pattern polishing, repair and laying-up). For a worker carrying out the polishing task the hygienists asked typically:

> "What is he doing?" (OH1)
>
> "What (substance) is he using?" (OH5)

Nine of twelve hygienists asked these or similar questions. The same situation was observed with the mould pattern repair task, which again is given high

prominence on the tape (where eight made inquiries). On the other hand, two hygienists did not ask any questions about either of these tasks. Since these individuals were not directly acquainted with the factory, it would not have been possible for them to know definitively what these workers were doing or substances they were using, simply from generic knowledge of GRP processing. This arguably reflects a lower performance in this aspect of the exercise.

11.3.2.2 Finishing task

There were several routes by which participants identified the finishing task and consequent dust hazard:

- *previous knowledge* - a number of hygienists were sufficiently familiar with GRP processing to realise there was likely to be a finishing task and they simply asked, for example:

  "What about finishing?" (OH6)

- *linking questions* - another route used by some was to employ linking questions in their general elicitation of the overall process. For example:

  "What happens next?" (OH1)

  "And what happens after the laying-up task?" (OH5)

  Only three from twelve hygienists explicitly used this approach. This allows a systematic elicitation of all seen and unseen tasks to ensure necessary coverage of the whole production process.

- *supplied resin hazard data sheet* - by reading this participants could find out about use of the resins and the associated dust generating finishing process.

In Table 11-4, below, seven hygienists explicitly identified the finishing task, with some asking further questions about this subject. For example, (OH1) asked a further nineteen questions about 'finishing'. This is very important, since hazard identification and risk assessment can only be explored further once the task itself has been identified.

Participant OH12 mentioned general protective measures needed for finishing, in passing, but did not enquire further about the finishing task at *this* factory. Participant OH12's additional (generic hazard-based) comment about the need for eye protection is not relevant, since unknown to this participant, the worker was already wearing an airstream-helmet type respirator fitted with a visor. The participant simply did not ask the appropriate questions to elicit this information.

Most members of the hygienists' group held to the objective of eliciting as many details of the production process as was possible given the constraints imposed by the experimental set-up.

11.3.2.3 Key aspects of process elicitation

Key features observed from occupational hygienist participants are identified below:

- asking a large number of questions to elicit process and task details;
- frequent re-capping to ensure clarity and continued understanding;
- using linking questions to elicit systematically the whole industrial process.

Surprisingly, in the consultations no-one in the hygienists' group (or indeed in any of the participant groups) tried to draw a plan of the factory or asked the manager to do this or to draw an outline diagram of the process logic. Only one participant drew their own process diagram during the consultation. (This participant was a trainee inspector and former Environmental Health Officer with extensive experience of investigating pollution incidents.)

As discussed above, some hygienists (and participants in the other groups) had varying prior generic knowledge of GRP processing. This may have been from direct personal experience in their work or hobbies, or knowing someone who worked in the industry. This knowledge was likely to have had an impact on their approach to, and performance in, the exercise. However, prior knowledge did not result in a consistent approach with different participants. For example, some hygienists, (with demonstrable prior knowledge) went through the exercise of asking numerous questions to identify, explicitly,

process tasks. In other words they approached the exercise probably in the same way as they would have approached a totally unknown industrial process. In contrast, others, also with prior generic knowledge, asked much fewer questions concerned with process elicitation. One hygienist demonstrated familiarity with the process by making the following opening statement:

> "Obviously it is a GRP factory; and I presume there is a lot of styrene around; I can smell it [!]; there are obviously several areas of interest; there is a flammable risk from solvents and styrene and so on - you obviously keep your drums of materials in the factory rather than outside; we should perhaps go outside and look and see if there is a proper safe area where these can be located in a proper safe compound ....." (OH12)

This highlights the importance of a sense of smell in HSRA for detecting some airborne contaminants, although, the absence of odour was of course a limitation with this exercise. This participant did not then proceed in the course of the consultation to ask many further questions concerned with eliciting the process. In contrast to this approach, OH1 (also familiar with the generic process) went through a formal elicitation asking seventy-nine further questions about process activities. (Both participants had had the standard pre-consultation briefing where they were asked to verbalise as much as possible and to ask confirmatory questions even where they were reasonably sure about matters.)

In the exercise briefing, participants were requested to ask confirmatory questions even where they were reasonably sure about the answer. This is important, since, with this method, if a question is not asked it will not be recorded and be included in the transcript. This could result in an underestimation of the performance of experts with prior generic knowledge.

Table 11-1 Process elicitation and task identification (mould preparation)

OH1	What is he doing there?	identify polishing
OH2	That chap is using a scouring substance?	identify polishing
OH3	Is that some sort of polishing?	identify polishing
OH4	No comment	
OH5	What is he doing?	identify polishing
OH6	What is the purpose of the silicone wax	identify polishing
OH7	He is preparing the mould there?	identify polishing
OH8	What is he using?	identify polishing
OH9	No comment	
OH10	No comment	
OH11	I am not sure why – he is polishing the mould itself?	identify polishing
OH12	So what is this operation?	identify polishing

Table 11-2 Process elicitation and task identification (resin activation)

OH1	Doesn't this [resin] have to be mixed with anything else?	identify resin activation
OH2	No comment	
OH3	No comment	
OH4	No comment	
OH5	Is there a catalyst there as well and they stir them together do they?	identify resin activation
OH6	What is in these materials [resin and catalyst;]	identify resin activation
OH7	Do you have to make any additions to the resin system or as soon as it comes into contact with the air it starts to cure on its own?	identify resin activation
OH8	What do they have to do here – they fill up a bucket [with resin] and ...?	identify resin activation
OH9	No comment	
OH10	No comment	
OH11	No comment	
OH12	No comment	

Table 11-3 Process elicitation and task identification (laying-up)

OH1	So you mix them together [resin and catalyst] and then what?	identify laying-up
OH2	This chap is bending over the vapour; this chap is using resins?	identify laying-up
OH3	This is laying-up the glass fibre matting?	identify laying-up
OH4	Can you tell me what the people are doing?	identify laying-up
OH5	These guys are laying-up glass fibre with resin?	identify laying-up
OH6	You mix your resin and catalyst – then what goes on?	identify laying-up
OH7	That is laying-up is it?	identify laying-up
OH8	Those guys in the background – what are they doing?	identify laying-up
OH9	I think I know it – styrene; I have seen similar things before;	identify laying-up
OH10	It looked like GRP work?	identify laying-up
OH11	So what are they applying? The glass fibre is applied to the doors and coated with resin	identify laying-up
OH12	Obviously it is a GRP factory?	identify laying-up

Table 11-4 Process elicitation and task identification (finishing)

OH1	When we have got the three layers on – what happens next?	identify finishing process
OH2	No comment	
OH3	No comment	
OH4	No comment	
OH5	What happens after laying up?	identify finishing process
OH6	We did not see the finishing workshop?	identify finishing process
OH7	What tasks is the finishing operator engaged in?	identify finishing process
OH8	With the sanding – there is probably a lot of noise?	identify finishing process
OH9	No comment	
OH10	I noticed that work was in preparatory stages – I did not see any use of power tools for sanding?	identify finishing process
OH11	No comment	
OH12	Need to wear eye protection against splashes and also when doing sanding	identify finishing process

Table 11-5 Process elicitation and task identification (mould repair)

OH1	What is this fellow doing?	identify repair task
OH2	No comment	
OH3	What is that guy doing?	identify repair task
OH4	No comment	
OH5	What is he doing?	identify repair task
OH6	What is he doing?	identify repair task
OH7	This is the repair work you mentioned earlier on?	identify repair task
OH8	What is this guy up to?	identify repair task
OH9	No comment	
OH10	No comment	
OH11	What is he using?	identify repair task
OH12	What is this operation?	identify repair task

11.3.3 TASK CHARACTERISATION (STAGE 3) AND HAZARD IDENTIFICATION AND EXPOSURE ASSESSMENT (STAGE 4)

A selection of the relevant transcript data are summarised in Tables 11-6–11-9 below. Once a task has been identified, then other information needs to be collected. This can be done both visually (by watching the task being carried out) if possible or non-visually (eliciting information by questioning management and ideally task operators themselves).

In this study where participants viewed a videotape, tracking *visual* task assessment was problematic, since participants observed and mentally noted key details, but sometimes did not verbalise them (ie, make a comment or pose a question). As was noted above, if something was not verbalised, then it did not appear on the transcript record. Some participants did take notes during the second viewing of the tape and visual observations were often written down. (Writing materials were provided for all participants.)

Much of the required information for the risk assessment could only be obtained by questioning the manager or consulting relevant documents. Such data would include, for example, identification of substances used in the tasks,

existence of substance hazard data, previous air monitoring information and whether there had been any reported health effects in exposed workers.

The following are examples of information obtained by visual task assessment:

> "You may be exceeding the [hygiene] limit - because .... they apply it themselves and they are having to lean over the mould all the time they are applying it - they apply it for long periods leaning over it with solvent evaporating across people's faces." (OH1)
>
> "This guy is cutting the glass fibre - he is not wearing any gloves?" (OH11)

11.3.3.1 Task time

Time spent on a task is a major determinant of the extent of exposure to a substance, and therefore, it was important for participants to gain an understanding of which tasks took longest and which were carried out most frequently:

> "How long does it take to lay up and put on the resin?" (OH3)

Surprisingly, only two hygienists explicitly asked about the time involved in the laying-up task. (This was the longest task for each moulder in the production cycle.) Those participants who possessed basic knowledge of GRP processing would probably have known this already and that other tasks, including mould pattern preparation, pattern repair, cutting glass fibre and resin activation, were relatively short duration activities (assuming no task specialisation).

Overall, only four hygienists explicitly mentioned *time* in their questioning on process tasks (Table 11-7). However, information on 'task time' overlaps with data gathering on 'task specialisation'. This is another route for finding out information about time spent on different tasks although not quite as precise as a direct question about each task (Table 11-15).

One hygienist asked three questions about time:

> "And how long does all this take?" [referring to laying up]
>
> "How long to apply three layers of resin and fibre glass?"
>
> "Does that include the waiting time?" [referring to curing] (OH1)

In a real factory, further information about tasks can be elicited by questioning the workforce, especially the 'task operator' ie, the person actually carrying out the work. In this study, the interviewing of workers was not possible and all information had to be obtained through the factory manager. Some participants mentioned a range of questions that they would like to have asked the workers directly about the way tasks are normally carried out, for example, whether they had noticed any health effects associated with their work and whether work conditions were typical on the occasion of the visit.

Other information was required on a range of factors including hazard data on substances and whether there had been any health effects in workers. The queries of the hygienists on these topics are given in Tables 11-8 and 11-9.

11.3.3.2 Current hazard data

Most asked the manager if he had any DHSS for the process. One participant did not ask this question but recommended that the manager obtain some, ie, the assumption was simply made that the manager did not have these. The final hygienist was quite familiar with GRP processes and did not ask about HDSs (Table 11-8).

11.3.3.3 Reported health effects in workers

Most hygienist asked the manager about reported health effects or complaints from workers and these were mostly concerned with skin problems and possible dermatitis (Table 11-9).

11.3.3.4 Relevant general information

Much relevant general information on the factory process and system of work was obtained by participants from the factory manager on a wide range of subjects:

"Do people do the same thing every day?" (OH1)

"How many shifts do you work?" (OH3)

"What hours do the men work?" (OH12)

limits are based on exposure over a typical eight-hour working day and the reasoning behind this questioning was to confirm that the workers were operating on this basis. With overtime working (asked about by three hygienists), the potential inhalation dose is higher and exposure tolerability standards would have to be adjusted to account for the longer period of exposure and also the reduced recovery times for the workers.

Table 11-6 Task characterisation (laying-up resin and glass fibre)

Participant	Questions/Comments	Task
OH1	Do you paint that [resin] on the mould by hand? How many layers would you do like this? So you would do one layer and then immediately start applying the next layer or would you wait? And how long does all this take? How long to apply three layers of mould resin and glass fibre? Does that include the waiting time? Does it get warm when it is curing?	Non-visual task assessment
OH2	No comment	
OH3	Is the resin always applied by brush? [no spraying] How long does it take to lay-up and put on the resin? Each layer? Do you have to leave it to cure between layers? Curing is done at room temperature - you do not have to heat it?	Non-visual task assessment
OH4	When these components [doors] are finished where do they go to dry off?	Non-visual task assessment
OH5	What about the laying-up process?	
OH6	How many layers? They are actually painting on the resin?	Non-visual task assessment Visual task assessment
OH7	Is there any kind of consolidation undertaken - you need to get a good mix between the resin and the mat; there is a lot of emphasis on the brush to achieve that; do you use any rollers for this particular process?	Both visual and non-visual task assessment
OH8	This is a sort of Pilkington glass fibre? How many of these layers do they put on? The curing process depends on temperature - it will cure too slowly otherwise which may affect the quality.	Visual task assessment Non-visual task assessment
OH9	No comment	
OH10	No comment	
OH11	This is the polyester resin? There is not an adhesive to first of all to put the glass fibre on to the pattern? They seem to be applying it [resin] very liberally - is that normal?	Visual task assessment Non-visual task assessment Visual task assessment
OH12	Laying-up is quite a skilled task?	

Table 11-7 Task characterisation (duration)

OH1	And how long does all this take? How long to apply three layers of resin and fibre glass? Does that include the waiting time?	duration of laying-up
OH2	No comment	
OH3	How long does it take to lay up and put on the resin	duration of laying-up
OH4	No comment	
OH5	So he will be doing that for a short period and then something else	duration of polishing
OH6	No comment	
OH7	No comment	
OH8	So the job he is doing will take time 30 min?	duration of mould repair
OH9	No comment	
OH10	No comment	
OH11	No comment	
OH12	No comment	

Table 11-8 Hazard identification and exposure assessment (health effects)

OH1	Are you aware of your employees ever having skin problems?	general – all tasks
OH2	No comment	
OH3	Do you get any complaints from workers about the smells from the resin? Any ill-effects? Do any of the workers suffer from problems with their skin from the glass fibre or resin?	general – all tasks
OH4	Has anyone complained of dermatitis? Has anyone ever been taken to hospital or overcome at the premises?	general –all tasks
OH5	Has he had any skin problems?	mould preparation (polisher)
OH6	Any respiratory problems? You haven't received any complaints about ill-effects?	general – all tasks
OH7	Any one had any adverse health effects – sore eyes, dermatitis?	general – all tasks
OH8	No dermatitis? Have you had any apparent skin problems? Do they have much in the way of back problems?	general – all tasks
OH9	Have you had any incidents – either cutting accidents or people complaining of ill-health?	GF cutting task general – all tasks
OH10	Do you get any complaints from the men? No sign or irritation? None of them is going to their doctors with skin conditions? They do not get headaches or anything like that?	general – all tasks
OH11	Has anyone been off sick at all with any allergic symptoms?	general – all tasks
OH12	No comment	

Table 11-9 Hazard identification and exposure assessment (hazard data)

	Participant Questions	Purpose
OH1	Have you got any data on the release agent? Have you any detailed information on the resins?	elicit hazard data on mould preparation; laying-up; activation and storage tasks
OH2	No comment	
OH3	No comment	
OH4	Have you got a list of all the hazard data sheets for the materials you are using? You have some hazard data sheets but not all?	elicit hazard data on all tasks
OH5	Have you a hazard data sheet for the wax? Have you got the hazard data sheets for the repair process?	elicit hazard data on mould preparation and mould repair tasks
OH6	The wax - have you got any information on that at all? Do you have any material data sheets? Have you tried soliciting any information from suppliers as to problems?	elicit hazard data on all tasks
OH7	Do you have copies of the hazard data sheets for these materials? Have you got a hazard data sheet for the catalyst? Of all the materials you are using on site this HDS is all you have got?	elicit hazard data on all tasks
OH8	You have not got a hazard data sheet for the fibre glass? These fillers often have health and safety guidance on them? Do you have any material safety data sheets?	GF cutting; laying-up Repair task elicit hazard data on all tasks
OH9	Have you got the data sheets?	elicit hazard data on all tasks
OH10	Have you got the hazard data sheets for the materials you are using?	elicit hazard data on all tasks
OH11	Moulding process - that's the one I have got the data sheet for? Have you got a safety data sheet for the polish? Have you got a data sheet for the filler? Do you have a data sheet for the resin?	laying-up; resin activation mould preparation mould repair laying-up; resin activation
OH12	Have you got a safety data sheet for the catalyst? Have you got any safety data sheets? (You should have them from your supplier) You have had this data sheet for quite a while have you? Have you got data sheets on most of these? Have you any written information by way of data sheets on any of the materials you are using?	resin activation elicit hazard data on all tasks

11.3.4 EVALUATION AND AUDIT OF CURRENT CONTROL MEASURES (STAGE 5)

Transcript data relating to evaluating/auditing current controls are summarised in Tables 11-10 to 11-14 below. Identifying control measures required knowledge of the principal options. The hygienists asked questions about a range of prospective measures which could have been in operation at the factory. This included both direct control measures (for example,

mechanical ventilation, personal protection equipment) and indirect measures such as the provision of training and information, previous air monitoring surveys and health surveillance programmes.

Indicative information relating to general management control (of health and safety risks) at the factory could be obtained from questioning about whether the company had a health and safety policy or any HS organisation. The manager's answers to some questions demonstrated his personal attitude to health and safety, which an assessor would want to take into account:

> "Have you got a company health and safety policy statement?" (OH7)

Participants enquired about the following (prospective) current control measures. Questions were applied to both the factory overall and to identified specific tasks (Occasionally it was difficult to distinguish between these two types of query. Topics included:

- general dilution or local exhaust ventilation;
- personal protective equipment (gloves, respirators, overalls, eye protection);
- health surveillance and pre-employment screening;
- information, instruction and training for workers and managers;
- resin spillage procedure;
- separate storage area;
- welfare facilities.

Since the factory had very little 'control' of its processes, the exercise usually required simply enquiring if a specific control existed.

11.3.4.1 Ventilation

Table 11-10 lists the questions raised by the hygienists with respect to current ventilation provision at the factory. Eleven hygienists asked about this subject. The other participant in the group (OH2) seemed to assume it was a problem,

but did not ask any questions to confirm this. Most questioning was concerned with the moulding area:

"Can the windows be opened?"

"Circular opening - is a wall mounted fan installed there?"

"Typical that the doors are left open?"

"Any mechanical ventilation (in the moulding work area)?"

Some questions were concerned with controls in the finishing shop:

"The sander has its own dust collection bag?"

"Finishing shop - is there any form of ventilation?" (OH7)

Interestingly, with this participant, even having asked the above six questions no subsequent recommendation was made regarding any action required on ventilation, although, the clear impression is left that this participant believes something should be done. Only one other participant (OH1) enquired whether there was a local extraction system built into the orbital sander used in finishing.

Most established that there were no mechanical ventilation systems in the factory (eleven hygienists) and explicitly that the open door was the major source of ventilation (eight). Participants were concerned about the adequacy of open doors as ventilation and some were concerned about the situation in Winter when the doors were closed:

"Any mechanical ventilation?"

"Only open doors?" (OH3)

"Is the open door the only source of ventilation?"

"What happens in Winter?" (OH5)

Thus, where ventilation sources were identified, participants were clearly concerned about their adequacy.

11.3.4.2 Personal protective equipment

In Table 11-11, eleven hygienists queried the position with regard to personal protective equipment (PPE), particularly the provision of gloves and respiratory protection equipment (RPE) for the moulders and where identified, the RPE regime for the sander:

> "Do workers have personal protection available to them? Gloves?" (OH11)

Most participants established a total lack of PPE provision and systems at the factory. (The protective clothing seen in the videotape was brought in by the workers themselves.) The above question establishes that the workers do not have personal protective equipment *available* to them. It is important to ascertain that workers are simply not using protective devices, which have been supplied. Questions were raised about availability of overalls (seven hygienists), the availability of gloves (six hygienists), and provision of RPE (three hygienists). The RPE regime used in the finishing area was queried by four hygienists. (Some hygienists recommended various types of PPE later in the consultation, but examination of transcripts revealed that participants sometimes did not ask questions to establish the actual existing position, but simply made assumptions based upon their impressions of the factory.)

With the finisher, once participants had established that his respiratory protection was theoretically adequate, they then queried the adequacy of arrangements to ensure this equipment's continuing effectiveness including maintenance issues (three hygienists.) For example:

> "Is the sander operator trained to use his RPE?"
>
> "Does he like using his RPE?"
>
> "Does he use it?"
>
> "Who looks after this RPE?"
>
> "Filters and charging batteries?"
>
> "Is the man himself responsible?" (OH5)

11.3.4.3 Air contaminant monitoring[1]

In the scenario, air contaminant monitoring had not been carried out previously out at the factory. Most participants established that this was the case (Table 11-12):

> "Has any test been taken to establish what the solvent vapour levels are?" (OH4)

Only one participant asked about dust monitoring:

> "Have you done any dust measurements?" (OH7)

However, three hygienists enquired about air monitoring in general, for example:

> "Have you had any air monitoring done?" (OH9)

[Styrene is included in Schedule One of the COSHH Regulations and has a Maximum Exposure Limit (MEL). This means that exposure must be reduced as low as is reasonably practicable and at all times the limit must not be exceeded. Its inclusion in Schedule One has taken into account evidence of its supected carcinogenicity potential in humans. On the above basis, one would expect queries as to whether air contaminant monitoring had been carried out at the factory.]

11.3.4.4 Health surveillance and pre-employment medicals

The COSHH Regulations 1994 (Schedule 5) prescribe some situations where health surveillance is always required. However, in most situations it is for the assessor to decide if health surveillance is appropriate. Three hygienists asked if there was any current medical or health supervision at the factory (Table 11-13). The remaining hygienists possibly assumed from the type and culture of the factory that established health surveillance was unlikely and therefore did not ask about this.

11.3.4.5 Information and training

Questions to identify the following training arose: on-the-job, first-aid, fork-lift truck driver, toxic substance handling and health and safety for management. This information is presented in Table 11-14. Ten hygienists asked some questions about training. Most commonly, queries concerned training and information for working with toxic substances and health and safety in general.

[1] In the subsequent development of the performance matrix it was decided to include 'previous air monitoring' under the 'Hazard Identification And Exposure Assessment' stage of the model.

information for working with toxic substances and health and safety in general. Some questioning on this was extensive as in the case of (OH4) below:

> "How are the employees given information, instruction and training with respect to the health hazards which may be associated with their work?"
>
> "What sort of training have they been given?"
>
> "That is training in how to do the job – what about hazards and so forth?"
>
> "Do they know what the chemicals are?"
>
> "Do they know that they may be harmful by skin contact or breathing them in?"
>
> "They obviously do not see health and safety data sheets?"
>
> "Are any records kept of the training?" (OH4)

Three hygienists were concerned with identifying any management training in health and safety. For example:

> "Have you, the manager, had any formal training in health and safety?" (OH11)

Table 11-10 Auditing current controls (ventilation)

Participant	Participant question	Data
OH1	No evidence of any fans or ventilation? There are not any mechanical ventilation systems installed? Are they just clear panels in the roof – they are not opening windows? Has the orbital sander [finishing] got an extractor bag on it?	identifies ventilation for moulding area tasks identifies ventilation for finishing area tasks
OH2	No comment	
OH3	Any mechanical ventilation? Only open doors?	identifies ventilation for moulding area tasks
OH4	What about ventilation in the shop? You have no LEV? What steps can you take apart from opening the doors? How hot does it get in your workshop?	identifies ventilation for moulding area tasks
OH5	Those louvres – are they vents? Is the open door the only source of ventilation? What happens in Winter? Are those previous fan holes? [in the wall]	identifies ventilation for moulding area tasks
OH6	Is there any local exhaust ventilation? Just doors and windows?	identifies ventilation for moulding area tasks
OH7	Can the windows be opened? Circular opening – is a wall-mounted fan installed there? Typical that the doors are left open? Any mechanical ventilation? The sander has its own dust collection bag? Finishing shop – is there any form of ventilation?	identifies ventilation for moulding area tasks identifies ventilation for finishing area tasks
OH8	Doors the only ventilation? Do the louvres or windows open?	identifies ventilation for moulding area tasks
OH9	Doors open but what about in Winter? No dedicated extract systems?	identifies ventilation for moulding area tasks
OH10	Is there a smell in Winter with the doors closed? No sign of ventilation?	identifies ventilation for moulding area tasks
OH11	Any roof vents? Any local exhaust ventilation? Mainly open doors? Doors open in Winter?	identifies ventilation for moulding area tasks
OH12	Not much ventilation? Can you open windows?	identifies ventilation for moulding area tasks

Table 11-11 Auditing current controls (personal protective equipment)

OH1	Have you got any gloves? What sort of helmet? Has that got some battery pack with some filters? And do you change the filters?	Identifies PPE for laying-up task Identifies PPE for finishing task
OH2	No comment	
OH3	Some are wearing overalls and some are in just casual clothes - do you provide overalls? Do you provide gloves or other PPE? Has anyone ever asked you for gloves?	Identifies PPE for moulding area tasks
OH4	Does anyone wear gloves at all? Overalls, I see the odd chap in overalls - do you supply overalls? No-one is wearing any mask?	Identifies PPE for moulding area tasks
OH5	I notice they are not wearing gloves? Is the sander operator trained to use his RPE? Who looks after this RPE?	Identifies PPE for moulding area tasks Identifies PPE for finishing task
OH6	Some had overalls and others didn't - is there any reason for that? Was the chap with the disposable TYVEK overall doing a special job? I notice they had tape on their wrists - why would they do that? What about the overalls? Are they supplied with gloves? What kind of mask does the sander wear? The unfinished door is finished by someone wearing an airstream helmet in a separate workshop? Do you have any information on the airstream?	Identifies PPE for moulding area tasks Identifies PPE for finishing task
OH7	They would normally wear just T-shirts with one in some coveralls? Resin - a messy job - what do you provide in the way of protective clothing? Do you provide any PPE at all? You just expect them to come to work suitably dressed? Are they provided with anywhere they could store personal clothes? You do not provide a locker? Company policy on safety shoes or anything like that? Some are wearing disposable overalls?	Identifies PPE for moulding area tasks
OH8	You do not provide warm Winter clothing? You do not have much PPE?	Identifies PPE for moulding area tasks
OH9	I saw cutting GF with no gloves or protection?	Identifies PPE for GF cutting task
OH10	One chap was doing some very fine work with his bare hands - I wonder how he cleans up afterwards?	Identifies PPE for repair task
OH11	Do workers have personal protection available to them? Gloves? You do not provide any PPE?	Identifies PPE for moulding area tasks
OH12	You do not provide any RPE? Some were wearing overalls?	Identifies PPE for moulding area tasks

Table 11-12 Auditing current controls (air monitoring)

	Participant Questions	Purpose
OH1	Have you had consultants to do measurements of fumes or solvents? Have you done air monitoring?	identifies previous solvent monitoring
OH2	No comment	
OH3	Have you had any measurements done on the concentration of solvents in the air?	identifies previous solvent monitoring
OH4	Has any test been taken to establish what the solvent vapour levels are?	identifies previous solvent monitoring
OH5	Have you every measured the airborne levels of styrene here?	identifies previous styrene monitoring
OH6	No comment	
OH7	Have you done any dust measurements? Have you done any measurements of the resins?	identifies previous dust monitoring identifies previous styrene monitoring
OH8	No comment	
OH9	Have you had any air monitoring done?	identifies any previous monitoring
OH10	No comment	
OH11	Have you ever made any measurements of exposure to substances in the workplace?	identifies any previous monitoring
OH12	Have you monitored/assessed the hazards at all under the COSHH regulations? Have you done any actual assessments or measurements? Do you have for instance a Draeger kit?	identifies any previous monitoring

Table 11-13 Auditing current controls (health surveillance)

	Participant Questions	Purpose
OH1	No comment	
OH2	No comment	
OH3	No comment	
OH4	If there were [skin problems] how would that be picked up?	identifies any medical checks?
OH5	Do you ever look into their medical background when you take them on? Does the company look into the job history of the people it takes on? How do you know that you have not taken on someone who has been working with toxic materials for many years, becomes affected and decides to sue you?	identifies any pre-employment screening
OH6	No comment	
OH7	No comment	
OH8	Do the guys have a pre-employment medical?	identifies any pre-employment screening
OH9	No comment	
OH10	Have you got a doctor?	identifies any medical input?
OH11	No comment	
OH12	No comment	

Table 11-14 Auditing current controls (information and training)

	Evaluation Question	Answer
OH1	No comment	
OH2	Have they been given any information on health and safety generally? Has the foreman been trained in health and safety? If I asked the foreman – what is that material and could he give me any information on the dangers – could he do that?	identifies lack of worker and management health and safety training
OH3	How long does training take? Do you have particular people who do the training? Can it be anybody who does the training?	identifies general job training
OH4	How are the employees given information, instruction and training with respect to the health hazards which may be associated with their work? What sort of training have they been given? That is training in how to do the job – what about hazards and so forth? Do they know what the chemicals are? Do they know that they may be harmful by skin contact or breathing them in? They obviously do not see health and safety data sheets? Are any records kept of the training?	identifies lack of worker health and safety training
OH5	Do they have any training in the hazards of the materials? That training is in how to do the job and not in the nature of the materials? Do the experienced moulders know what the problems are with the substances? Is the sander operator trained to use his RPE? Has the foreman had any health and safety training? Have you, the manager, had any health and safety training?	identifies lack of worker and management health and safety training identifies RPE training for finisher
OH6	What about training of people in this area? The training is job training rather than problems associated with materials and so on?	identifies lack of worker health and safety training
OH7	When someone new starts – is he given any training on what the health risks might be? Training is a sitting with nelly situation? On the health and safety front it is what they might pick up from other people?	identifies lack of worker health and safety training
OH8	What sort of training do they get? Any information on health and safety matters is a bit by chance? It depends on the moulder and his experience?	identifies lack of worker health and safety training
OH9	No comment	
OH10	Your FLT driver has been trained?	identifies FLT training
OH11	Have you the manager had any formal training in health and safety?	identifies lack of management health and safety training
OH12	Have you done a safety course?	identifies lack of management health and safety training

11.3.5 IDENTIFYING EXPOSURE WORKGROUPS AND TASK SPECIALISATION (STAGE 6)

Transcript data from the occupational hygienist participants is summarised in Table 11-15 below:

This is grouping workers on the basis of their exposure to hazardous substances and the identification of task specialists. As well as considering task operators, the position of other ancillary staff such as labourers, maintenance staff and cleaners is queried.

Questions were then asked to determine specialisation, ie, whether the task a worker was doing on the videotape was the sole, or major component of, his work. Effectively, in the scenario, participants were investigating the exposure of a typical 'moulder' and a typical 'finishing operator'.

From Table 11-15, it can be seen from that ten from twelve of hygienists recognise the importance of task specialisation and ask about division of labour. Questions were often asked with reference to a worker carrying out a particular task, for example, polishing:

> "Is this the polisher's permanent job or does he rotate with the others?" (OH11)

> "Do they cut their own strips or do you have a production flow where someone is specialising in that?" (OH12)

The answer to this question was generalisable in the sense that all workers (excepting the finisher) were 'moulders' with similar duties. Therefore, once participants had this answer, they did not have to ask about specialisation again for each tasks observed.

Table 11-15 Identifying workgroups and task specialisation

OH1	Do people do the same thing every day? Does he do that all day? So they switch jobs and take it in turns? (cutting GF)	identifies specialisation
OH2	No comment	
OH3	The cutter - is that all he does? The others would be involved in mould cleaning, applying release agent, repair etc. ?	identifies specialisation
OH4	The chap cutting the glass cloth – could he be doing that all day long?	identifies specialisation
OH5	So he will be doing that (polishing) for a short period and then doing something else? Is the work on this process continuous?	identifies specialisation
OH6	The sanding - is that a rotated job? They rotate the tasks?	identifies specialisation
OH7	What is the current workpattern at the factory?	identifies specialisation
OH8	Do people stick with a range of jobs? Most of them take the process through from beginning to end?	identifies specialisation
OH9	No comment	
OH10	I saw them doing particular jobs, but I guess they do other things?	identifies specialisation
OH11	Is this the polisher's permanent job or does he rotate with the others? These guys are the same as the others and they all move between jobs? Eight people in the workshop doing essentially the same job?	identifies specialisation
OH12	What hours do the men work? Do they cut their own strips or do you have a production flow where someone is specialising in that?	identifies specialisation

11.3.6 COMPARING THE ESTIMATED EXPOSURE PROFILE WITH DERIVED TOLERABILITY STANDARD (STAGE 7) AND CONCLUSION ON TOLERABILITY OF HEALTH RISK (STAGE 8)

Transcript data from the hygienist participants is summarised in Table 11-16 below. Eleven hygienists *provisionally* concluded that estimated exposures were probably in excess of the tolerability standard for styrene vapour inhalation (in this case the MEL) or were sufficiently concerned to want air monitoring checks. Two from twelve hygienists were concerned about inhalation exposure to glass fibre to want air monitoring of this particulate. Typical comments were:

> "You may be exceeding the (exposure) limit." [for styrene inhalation]
> (OH1)

> "You have not had any monitoring done and .... it is likely that workers are overexposed to styrene. There are exposure limits which need to be applied relating to the exposure of workers to hazardous substances."
> (OH3)

> "Need an occupational hygiene investigation to check on the exposure of people - especially the intensive brushing application. Either measure or assume significant levels." (OH4)

> "The levels may be high and above the MEL [for styrene]." (OH5)

One participant was less definitive about exposures:

> "I am slightly concerned about styrene exposure." (OH6)

Collective reasons for these conclusions were:

- the laying-up task takes up most of the moulders' time every day;
- significant quantities of styrene resins are used in the process;
- styrene is a volatile liquid and readily produces a harmful vapour;
- there is a MEL limit for the vapour which clearly defines legal compliance;
- the moulder's breathing zone is in close proximity to the emitting surface during the task;
- the surface of the moulding is large and efficient at causing the evaporation of styrene vapour;
- the moulders do not have any respiratory protective equipment;
- there was an absence of other control measures including ventilation.

Further, some concluded that the health risk from exposure to styrene vapour would be intolerable in the foreseeable circumstances of a significant spillage of resin and that further control measures were necessary to protect against this contingency too.

Most participants concluded that the health risk from skin contact exposure with both the liquid resin and the fibre glass was intolerable and that further control measures (gloves and other PPE) were needed. Often this conclusion on risk was the inference made from many of their other comments rather than said directly:

> "Need to wear gloves and cover up skin." (OH5)

Of those participants who identified this workgroup, most thought that although the risk from inhalation exposure to sanding dust was under

reasonable control by effective RPE, they wanted more information regarding the maintenance regime for this equipment. One participant thought that the health risk from the vibrating sanding tool was significant and that further control measures were required:

> "Control (sander vibration) by buying a vibration-damped tool and wearing gloves to keep his hands warm." (OH1)

This participant also thought there was a significant health risk from noise exposure to the finisher and that further control measures were needed:

> "You could either get the noise measured or just buy some of those disposable ear plugs. It is probably not worth measuring. Plugs because it is difficult to wear muffs with a helmet." (OH1)

Table 11-16 Comparing exposure profiles with tolerability standards

OH1	You may be exceeding the limit: because of the quantity of the resin you are using. It is used by people manually apply themselves and are having to lean over the moulds all the time. They are applying it over long periods and leaning over it when the solvent is evaporating into their faces. Next you do not want resins on their skin	identifies exposures [to styrene] in excess of the air quality standard identifies intolerable skin contact with resin
OH2	No comment	
OH3	It is likely that the workers are being overexposed to styrene;	identifies intolerable exposure to styrene
OH4	Either measure or assume significant levels [exposure to styrene vapour during laying-up]	identifies probable intolerable exposure to styrene vapour
OH5	It strike me that airborne levels of styrene may be very high and maybe above the MEL Need to wear gloves and cover up skin	identifies probable intolerable exposure to styrene vapour identifies intolerable skin contact with resin
OH6	I am not in a position to make any judgements since I did not go down to any measurements; slightly concerned about exposures to styrene Probably problems with skin contact	identifies possible intolerable exposure to styrene; identifies likely skin contact with resin
OH7	Need some monitoring of styrene exposures	identifies possible problems with styrene exposure
OH8	I suspect that your styrene levels in the latter half of the day would be pretty high and you would certainly have to do something fundamental on that	identifies probable intolerable exposure to styrene;
OH9	No comment	
OH10	I would like to get some exposure measurements - principally styrene; I worry about their skin exposure	identifies possible problem with styrene exposure. identifies likely skin contact with resin
OH11	Would need to monitor for styrene and glass fibre	identifies possible problem with styrene and glass fibre exposure
OH12	I think you should look at your levels of solvent vapour; it is possible to get large quantities of styrene vapour building up in the atmosphere	identifies possible problem with styrene exposure

11.3.7 PRIORITISATION OF TASKS FOR CONTROL MEASURES BASED ON RISK (STAGE 9) AND RECOMMENDATIONS (STAGE 10)

These were priorities and formed the basis of subsequent recommendations made:

- health risk from styrene vapour inhalation - laying-up was the key task. (Although, this task was the largest contributor to exposure, participants

were aware of other sources, for example, from resin activation and mould curing.) However, laying-up was the key task to be controlled to reduce exposure to styrene vapour;

- health risk from skin contact with styrene-based resin - laying-up was thought to be the key task for application of control measures, suitable gloves in this case;
- health risk from skin contact with glass fibre - laying-up and glass fibre cutting recognised as key tasks, suitable gloves recommended in this case.

Short-term control measures suggested for the laying-up/GF cutting tasks were suitable overalls, gloves and a protective face mask together with health and safety training for the operators, air monitoring measurements and health surveillance. Medium-term measures included segregation of parts of the process (curing) and looking at the feasibility of installing a local exhaust ventilation system for the laying-up task.

11.3.8 RECOMMENDATIONS FOR ACTION (STAGE 10)

Transcript data relating to recommended action (from the occupational hygienist participants) is summarised in Tables 11-17 to 11-22 below.

11.3.8.1 Hazard data sheets (Table 11-17)

Most participants recommended that the manager obtain the hazard data sheets for the substances in use.

11.3.8.2 Personal protective equipment (Table 11-18)

Most participants established a general lack of PPE and recommended provision of suitable gloves, protective masks (in the short-term) and overalls while other control options could be looked at in the medium term.

Participant (OH1) recommended with regard to the moulding tasks involving styrene and glass fibre exposure:

> "Check what exposure is - if above the limit then short-term a face mask, charcoal filter half mask covering their nose and mouth."

> "You should get some better gloves, barrier cream and cleansing agent to help with skin protection."

> "Glass fibre - handling without protection will give very itchy skin, probably the same gloves as for the solvent will do." (OH1)

And concerning maintenance of protective clothing and equipment:

> "You should provide them with overalls at your expense and arrange laundering." (OH5)

11.3.8.3 Air monitoring survey (Table 11-19)

Nine hygienists wanted to carry out air monitoring of contaminant [styrene vapour] levels in the moulding work area The perceived importance of obtaining such data was indicated by the following comment:

> "Number one job is to find out what is the airborne concentration (of styrene vapour) in the breathing zone of those workers." (OH5)

The principal objective of monitoring was to measure the personal exposure of the moulders to styrene vapour since it would allow a confirmatory conclusion on risk tolerability, legal compliance and whether further control measures were necessary:

> "Control measures (engineering or personal protection equipment) will depend on the results of monitoring."

> "If above (the limit) - short-term PPE face mask either charcoal filter device half mask over their nose and mouth; if a long way over the limit you would need to look at a more permanent solution such a LEV." (OH1)

To a lesser extent (three hygienists), dust monitoring was recommended for both airborne glass fibre in the moulding area and to quantify dust exposure levels in the finishing area:

> "I would like to look at dust monitoring in more detail, maybe do some monitoring there [in the finishing shop], but get a feel for it by using a dust lamp in order to assess the RPE." (OH7)

Several participants went into further detail, suggesting 'worst case' monitoring during the Winter, when the factory doors were closed. One participant was perhaps a little too cautious when he commented:

> "I am not in a position to make any judgements since I did not go down to any measurements. I am slightly concerned about styrene exposure."
> (OH6)

(Possibly to avoid this, the briefing could have noted that visitors were unlikely to be able to re-visit the factory in the near future and therefore, they should make best use of the information gleaned from the present visit.)

As discussed in Chapter Two, the history of occupational hygiene has been marked by the development of a wide range of monitoring methods and techniques both to characterise and quantify airborne contaminants in order to decide on risk tolerability and adequate control. Thus, it is not surprising, that most hygienists concluded that working conditions were such that an air monitoring survey was needed. From the limited information at their disposal, four hygienists speculated that the moulders were exposed in excess of the (MEL) limit.

11.3.8.4 Health surveillance (Table 11-20)

This was recommended by four hygienist participants and proposals were targeted at detecting skin irritation and dermatitis. Of the four recommending health surveillance, two participants made the important point that this did not mean necessarily engaging medical professionals, that the foreman or the manager himself could look for possible skin problems in the workforce. On the other hand some did recommend the employment of a doctor or nurse. There were also some concerns about the effect of exposure to styrene vapour on the nervous system.

11.3.8.5 Health and safety information and training (Table 11-21)

Nine hygienists recommended some form of training for the workforce and most wanted information/training on process toxic substance hazards. Three participants specifically wanted better labelling on the resin drums. Overall a wide range of potential training topics were indicated including: first aid; fire-fighting; hazards from handling chemicals and protective measures.

11.3.8.6 Improve general/local ventilation (Table 11-22)

This was proposed for consideration as a medium-term control measure. One participant made no comment or asked any questions on this topic as regards the factory. However, a vague and half-hearted recommendation was made regarding new ventilation equipment. This participant had presumably concluded from viewing the videotape that ventilation provision was inadequate:

> "Put ventilation down as a heading. A unit is available to draw out these vapours and they are not expensive." (OH2)

Participant (OH1) recommended that when a new power sander was purchased by the Company, it should have an integral local extraction system. After previously asking about the conditions in the work area, participant (OH7) made no further comment or recommendation about 'ventilation'. This may have been because he felt unable to comment because he had no air monitoring information. Although participant (OH10) did not enquire about the finishing process or the orbital sander, he suggested that there was a need to look at having an extraction system built into the sander. Two participants, (OH9) and (OH7), made no explicit recommendations, which could be categorised under 'ventilation'. However, both identified clearly that there were no dedicated ventilation systems at the factory.

> "I am not in a position to make any judgements, since I did not go down to any measurements. I am slightly concerned about styrene exposure." (OH6)

They felt they could not say more without further information. The other ten participants believed that the provision of better ventilation was a necessity - usually more definitely in the case of dilution ventilation and 'probably or possibly' in the case of local exhaust ventilation. With some participants the recommendation was brief and non-committal, whilst in other cases, there was considerably more detail. It is interesting to contrast the brief and uninformative recommendation:

> "It is likely some sort of ventilation is required." (OH3)

with the following prescriptive and costed option:

> "Either measure or assume significant (air) levels and take appropriate action - two options: LEV ducting, 6 workstations £6000 or fit the men up with masks. Also have to maintain, examine and test once per year so there is the cost of that too; system will last about 15 years; general ventilation will control your heat problem, but may not control your solvent problem." (OH4)

The following comment was from a hygienist who specialised as a ventilation engineer and who had considerable practical experience in this particular area:

> "The problem with GRP manufacturing is that the products are large and difficult to enclose in a hood, booth or enclosure; it is quite a skill in providing satisfactory ventilation in a place like this; Solution - need to work out the amount of styrene given off; the flow of air needed to dilute this adequately and then decide how to introduce this into the room; I would need to work on detailed advice and spend 1-2 days at the factory." (OH5)

Former fan-holes in the wall were observed by two participants OH5 and OH7, the latter commenting that it may be worthwhile reinstating fans at these points.

11.3.8.7 Other control measures

A range of other current control measures relating to toxic substance risks were queried with the factory manager with these represented in the analytical matrix used below. These included first-aid provision, storage and handling of hazardous substances, housekeeping, the disposal of waste, factory spillage procedures.

11.3.8.8 Non-substance health hazards and risks

In the briefing, participants were asked to "assess health risks and make recommendations for action." Some hygienist participants appropriately queried the possibility of other health risks arising from - noise, lighting, manual handling, repetitive strain and other hazards. Recommendations for action were made regarding these hazards. Overall, however, the vast majority of participants focused on the health hazards and risks arising from exposure to the hazardous substances in use at the factory.

11.3.8.9 Safety hazards and risks

Participants were requested to address 'health' risks, although if this was queried, they were informed that they were welcome to comment on other 'safety' hazards, as long as they kept the emphasis on 'health' risks as requested in the briefing.

Risks arising from fire, electricity, storage and fork-lift truck hazards featured prominently in discussions. Fire risk was a major concern of virtually all participants in the study (across the specialist groups).

This was gratifying since fire was actually the most pressing and worrying risk at the factory. It was welcome that participants, having been given the priorities expressed in the briefing and its focus, still felt compelled to comment this as an intolerable risk (even if they felt that tackling this in detail was beyond their expertise). This did not require a complicated technical analysis of the fire hazard, principally a mention that the resin drums appeared to present an intolerable risk and that the company needed to do something about their storage. It would have been worrying if any 'health and safety' specialist on recognising the such a risk did not feel compelled to comment especially when visiting a small factory.

Table 11-17 Recommendations (substance hazard data)

OH1	No comment	
OH2	Contact supplier and ask for hazard data sheets for all the substances; look at the data sheets and then we can decide on PPE.	
OH3	No comment	
OH4	Obtain up to date hazard data sheets for all products you are using at the factory; contact the supplier. Make an inventory.	
OH5	You should get the hazard data sheets for all of your chemicals.	
OH6	You need to get information on all the materials you are using since I do not know what is in them.	
OH7	Set up simple inventories. Obtain hazard data sheets.	
OH8	Contact your main suppliers and get your information together.	
OH9	No comment	
OH10	Check hazard data sheets and other sources of information; let me know and I can get you a sheet; styrene will probably be number one but I do not like acetone in cleaning.	
OH11	You have got very poor information about the substances which you have - you need to obtain the safety data sheets from suppliers which should conform to the regulations so that you get precise information of the chemicals; this is to know something about the health effects of the chemicals and how they can enter the body - through the skin or by inhalation.	
OH12	Perhaps first of all you need to obtain a complete set of hazard data sheets from your suppliers.	

Table 11-18 Recommendations (personal protective equipment)

	Participant Recommendations	Comments
OH1	Check what exposure is – if above the limit then short-term a face mask, charcoal filter half-mask covering their nose and mouth. You should get some better gloves, barrier cream and cleansing agent to help with skin protection. Glass fibre – handling without protection will give very itchy skin; probably the same gloves as for the solvent will do. Control [sander vibration] by buying a vibration-damped tool and wearing gloves to keep his hands warm. You could either get the noise measured or just buy some of those disposable ear plugs (It is probably not worth measuring). Plugs because it is difficult to wear muffs with a helmet.	moulding area tasks– solvent vapour exposure GF cutting task finishing task
OH2	Look at the data sheets then we can see what PPE they need.	moulding area tasks
OH3	Short-term one way to protect people is to provide PPE – respirators of a suitable type to protect against solvent vapours - no monitoring done and it is likely workers are overexposed to styrene.	moulding area tasks styrene vapour exposure
OH4	No-one is wearing gloves and there is a lot of skin contact with chemicals – I know there is a dermatitis risk; probably disposable PVC gloves would do the job for non-immersion situations – disposable since re-usable develop pin holes. GF cutter needs gloves and disposable overalls; dust check to see if extraction or mask is needed. RPE – suggest charcoal disposable masks; with re-usable there is the problem of how often you change them and solvent breakthrough. Have to inspect re-usable PPE at monthly intervals under COSHH; also coveralls, need right grade, disposable once per week; must be readily available and employees must know.	moulding area tasks GF cutting task moulding area tasks solvent vapour exposure
OH5	Those guys must be wearing gloves and covering up their arms. You should provide them with overalls at your expense and arrange laundering. You should provide adequate gloves - need to discuss with the supplier; might need some respiratory protection while the ventilation is put right.	moulding area tasks
OH6	Mask to prevent the inhalation of glass fibre – we will use it as the first line until we know whether we can control it by other means. Slightly concerned about exposures to styrene and again in the short-term we could look at the possibility of using a respirator to prevent unnecessary exposure. Prevent skin contact with overalls – disposable or terylene but not cotton because that tends to take up the fibres. Sanding process – I would like to see the Airstream helmet which under COSHH must be inspected every month.	GF cutting task moulding area tasks styrene vapour exposure finishing task
OH7	No comment	
OH8	You have quite a lot of jobs with potential for skin contact.	moulding area tasks

Table 11-18 (cont'd)

OH9	Not happy with the lack of overalls. Tyvek overalls and boiler suits - I would be asking about that. If they should be wearing Tyvek overalls - then they should be wearing them when it gets hot. If they should be wearing gloves or any sort of protection then they should be wearing it.	moulding area tasks
OH10	Airstream helmets are fine when they are maintained. I am worried about their skin exposure - there were some gloves. Need aprons, gauntlets, gloves. On the fine work they will probably say they can't do it with gloves - I suggest surgeon's gloves, lightweight and disposable; the heavy gauntlet is fine if they do not need sensitivity of touch, but a finer glove may be better.	finishing task
OH11	In the short-term you may choose to use PPE in the prevention of exposure; particularly with glass fibre you should use gloves to prevent dermatitis; Possibly respiratory protection against styrene and glass fibre; styrene can cause dermatitis. Currently there is no PPE at all and scope for high levels of exposure You should implement the use of protective clothing	moulding area tasks GF cutting task styrene vapour exposure
OH12	[Commenting on HDS] - gloves, eye shield, footwear required. Here [laying-up] they are both wearing overalls but no eye protection or gloves. He is wearing an overall but it is rolled down to his waist. You should be providing PPE; overalls should be worn and not rolled down. Need to wear eye protection against splashes and also when doing sanding. The onus is on them to wear what is provided for their safety. Also overalls, gloves against spillages and splashes - probably butyl rubber it says on the data sheet - you need to make sure the gloves are the right material for the substances you are handling.	moulding area tasks laying-up

Table 11-19 Recommendations (air monitoring)

	Participant recommendation	Comment
OH1	You may be exceeding the (exposure) limit. Need to check their exposure - styrene is volatile and will evaporate past people's faces; control measures (engineering or personal protection equipment) will depend on the results of monitoring.	styrene monitoring
OH2	No comment	
OH3	You have not had any monitoring done and [...] it is likely that workers are overexposed to styrene. There are exposure limits which need to be applied relating to the exposure of workers to hazardous substances.	styrene monitoring
OH4	Need an occupational hygiene investigation to check on the exposure of people - especially the intensive brushing application. Either measure or assume significant levels.	not specific
OH5	The levels may be high and above the MEL. Number one job is to find out what is the airborne concentration in the breathing zone of those workers. You have got to get COSHH assessments, which will include establishing the airborne levels of the pollutants and the fibre.	not specific
OH6	I am not in a position to make any judgements since I did not go down to any measurements. I am slightly concerned about styrene exposure.	styrene monitoring
OH7	COSHH - need to think of some form on monitoring for the styrene exposures using Draeger short term tubes; I would like to look at dust monitoring in more detail, maybe do some monitoring there but get a feel for it by using a dust lamp in order to assess the RPE.	styrene monitoring finishing task
OH8	I suspect that your styrene levels in the latter half of the day would be pretty high.	styrene monitoring
OH9	If we need to do any personal air monitoring done - perhaps we could arrange that.	not specific
OH10	Would like to come in the Winter and take some measurement - personal samplers to measure styrene exposure; get someone in to do measurements and compare with HSE limits.	styrene monitoring
OH11	Instigate some monitoring - those with MELs - styrene and glass fibre; (under COSHH you are also concerned with health surveillance) Consultant needs to adopt a strategy for representative results; first monitor a 'worst case' exposure - high load in Winter when the door is closed.	styrene and glass fibre monitoring
OH12	You should look at your solvent vapour in the atmosphere; styrene has an MEL value; Carry out measurement of styrene levels. Need to get someone in to do the baseline assessment. You might want to get detector tubes for spot checks.	styrene monitoring

Table 11-20 Recommendations (health surveillance)

	Participant Recommendations	Comments
OH1	No comment	
OH2	No comment	
OH3	Consider medical surveillance as regards inspection of skin – dermatitis or similar skin problems from irritation and solvents which could come into skin contact.	dermatitis
OH4	Foreman should inspect the forearms of people weekly or fortnightly to ensure that obvious signs of dermatitis are not overlooked and asking people if they are getting any problems with hands and forearms – just look for rashes or skin irritation.	dermatitis
OH5	I think you should engage an experienced occupational health nurse to look into job and medical history. If you are taking people from similar sorts of work you may be taking on sick people and get the blame and be sued.	not specific
OH6	No comment	
OH7	No comment	
OH8	No comment	
OH9	No comment	
OH10	You and the foreman talk to the men to see if they have got any complaints, headaches, eye irritation, skin irritation. Could possibly get some medical checks on the men. Next time you go round have a look at the skin of the men yourself – you do not need to be a doctor to see someone with chapped skin.	skin problems
OH11	You seem to have a very high turnover of staff; health surveillance is prescribed (by COSHH) when you have an identifiable health condition resulting from exposure to a particular agent (glass fibre can lead to contact dermatitis and styrene can lead to changes in nerve conduction times - which can be tested	dermatitis
OH12	No comment	

Table 11-21 Recommendations (information and training)

OH1	No comment	
OH2	Good idea to have a trained first aider. Need [health and safety] training on various tasks. Fire-fighting training. Drum labelling.	support the need for various types of training
OH3	No comment	
OH4	Employees must have access to the health and safety data sheets. They must know that you have them and what arrangements have been made for them to access them. Employees have got to be told basically what the hazards are from handling the chemicals - harm due to skin contact, dermatitis, problems with the inhalation of vapour. Labelling of drums.	supports better information and substance hazard data supports better labelling information
OH5	I suggest you buy the COSHH regulations and see what your legal obligations are. Summarise the content of the HDSs and issue them to the men - back that up with training where you can tell them what materials you are handling and what you are providing to protect them	supports better health and safety information for both management and the workforce
OH6	I think that you could do with a bit of training. People should be aware of the hazards that are present in the workplace. Also welfare aspects such as eating in the work-area; drum labelling.	supports worker health and safety training; improved labelling information
OH7	Provision of information, instruction and training for employees	supports worker health and safety training
OH8	Some training.	not specific
OH9	Talk to them - give them some information.	not specific.
OH10	Go through what labelling is required with your foreman - get the information from the hazard data sheet. You want to get some information on COSHH.	supports the need for better information on health hazards for the management
OH11	Need to attend to information and training under COSHH; workers should be trained in the use of control measures implemented, the use of personal protective equipment, substance health effects and precautions; labelling of drums.	supports health and safety training on specific issues relating to COSHH better labelling information
OH12	It is important to give information and training on the results of your [air monitoring] survey.	supports better information and training on toxic substance risks

Table 11-22 Recommendations (ventilation)

	Perceptual Recommendations	Comments
OH1	Need to provide some ventilation.. (You would be exceeding the limit.) If a long way over the limit, you would need to look at a permanent solution such as LEV, but this is difficult to design for the work you are doing. Next time the sander is replaced get one with an extractor bag on it.	moulding area finishing area
OH2	Put ventilation down as a heading. A unit is available to draw out these vapours and they are not expensive.	moulding area
OH3	Likely some sort of ventilation is required.	moulding area
OH4	Either measure or assume significant [air] levels and take appropriate action - two options: LEV ducting, 6 workstations £6,000 or fit the men up with masks. Also, have to maintain, examine and test once per year so there is the cost of that too; system will last about 15 years; general ventilation will control your heat problem, but may not control your solvent problem.	moulding area
OH5	Problem with GRP manufacturing is that the products are large and difficult to enclose in a hood booth or enclosure; it is quite a skill in providing satisfactory ventilation in a place like this; Solution - need to work out the amount of styrene given off; the flow of air needed to dilute this adequately and then decide how to introduce this into the room; Would need to work on detailed advice and spend 1-2 days at the factory. With a new ventilation system - heating costs significant - radiant panels would be useful. Could reinstate the fans.	moulding area
OH6	Greater degree of ventilation depending on what found by monitoring; if high exposures then look at LEV in the cutting and laying-up areas. I am not in a position to make any judgements since I did not go down to any measurements. The [COSHH] Regulations lay down certain requirements and small organisations with limited money still have to satisfy those requirements.	moulding area - cutting and laying-up areas
OH7	No comment	
OH8	Laying-down process may require push-pull ventilation.	moulding area
OH9	No comment	
OH10	May need to improve your ventilation; there may be places where you want to put some local air extract. problems with exhaust hoods people will not work up close and increases heating bills; complaints from neighbours of styrene smell. With the finishing process - need to look at extract built into the sander and general ventilation;	moulding area finishing area
OH11	Investigate enclosing as many operations as possible by LEV; no dilution ventilation except for the doors which are closed in Winter and vapour accumulates.	
OH12	Almost certainly need extraction put in; May well find you are going to have 'significant expense' on ventilation - either local exhaust in areas which have high levels or general ventilation; anyway because there is very little in the work-area. Look at general flow of work and allocate certain areas where you could have good extraction and in areas where you could have less vapour have more general ventilation.	

11.4 TRANSCRIPT PERFORMANCE ANALYSIS OF THE SPECIALIST GROUPS

11.4.1 OVERALL SCORES IN MAJOR SUB-DIVISIONS OF THE MATRIX

There now follows an analysis of the performance 'score' for the occupational hygienists and the other specialist groups in the risk assessment exercise. Analysis was carried out using the purpose-designed matrix which has been described in Chapter Ten. The full data used in this analysis is given in Table 11-23 (Insert) and a summary is presented in the histograms below (Figures 11-1 to 11-22) focusing on eight sub-divisions of the matrix (itself broadly based on HSRA model B).

Individual participants in each group are ranked according to their scores and the five groups are plotted alongside each other to allow visual intra- and inter-group comparisons to be made. Median scores are used as an indication of overall group performance. (Median values, as an index of central tendency in a group of values, are less affected by 'outliers' than are arithmetic mean values.)

In terms of overall performance in the exercise the occupational hygienist group achieved the best scores. However, there was considerable individual variation within this group with two participants (noted in earlier discussion) achieving consistently low scores in the exercise. One of these participants did not enter into the spirit of the role-play situation and therefore seemed not to fully engage with the task. The other participant did engage in the role-play but seemed to be more interested in assuring the manager that the problems were not insurmountable. This person did not systematically tackle the set scenario. In both cases considering the background and experience of the individuals concerned it is very difficult to believe that they did not have the expertise to tackle the set problem. They were briefed in the same way as all the other participants and the experimental set-up was the same, but as to their evaluated performance, this was quite poor.

With a matrix containing a total of 137 classification categories it is difficult to make overall generalisations. The occupational hygienists (OHs) performed

well in all the major sub-divisions notably in the 'Process elicitation and task identification'; 'Task characterisation' and 'Recommendations - specific controls' divisions. The occupational health physicians (OHPs) performed well in the 'Hazard identification and exposure assessment division', the health and safety practitioners (SPs) in the 'Evaluation and audit of current control measures' and the occupational health nurses (OHNs) in the 'Recommendations - general controls' divisions of the matrix. The trainee health and safety inspectors (HSIs) also performed well in many of the different scoring categories of the matrix. and this was particularly the case with 'process elicitation and task identification/characterisation'. Figures 11-1 and 11-2 give the overall rankings of participants and their groups in the exercise.

Figure 11.1 Overall ranking

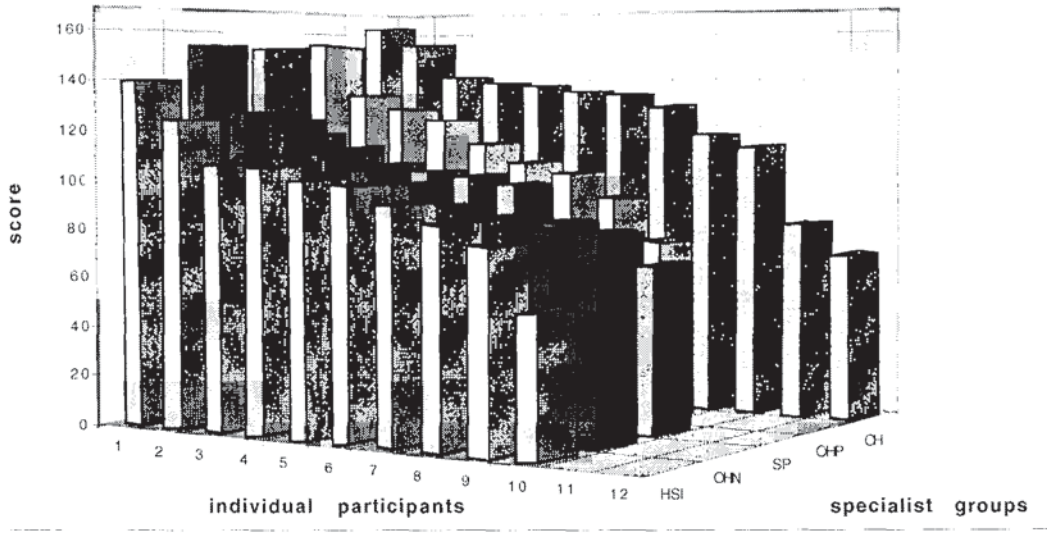


Figure 11.2 Overall ranking – median scores

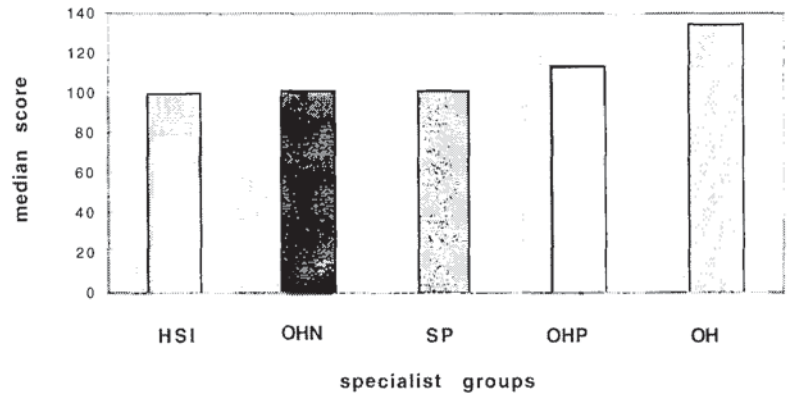


Figure 11-3 and 11-4 represent the performance of the five specialist groups in the 'Process elicitation and task identification' division of the matrix. The hygienist group performed particularly well here. Most of this group were systematic and thorough in their approach. Some OH participants asked many detailed questions to elicit the nature of the process and tasks. Aspects of their performance in this have been discussed above (11.3.2). The highest-scoring

trainee inspector possessed a Diploma in environmental pollution and had several years experience in the investigation of pollution incidents. He had clearly developed expertise in the elicitation of industrial processes and tasks. HSI participants score well in this area, possibly because they have developed skills when visiting different premises in efficiently eliciting and clarifying basic process details.

Figure 11.3 Process elicitation and task identification

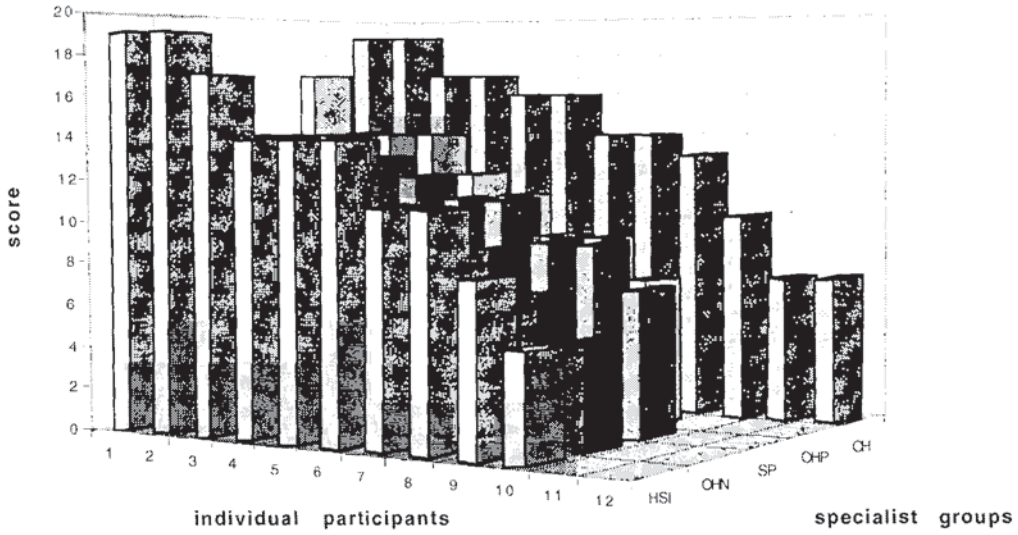
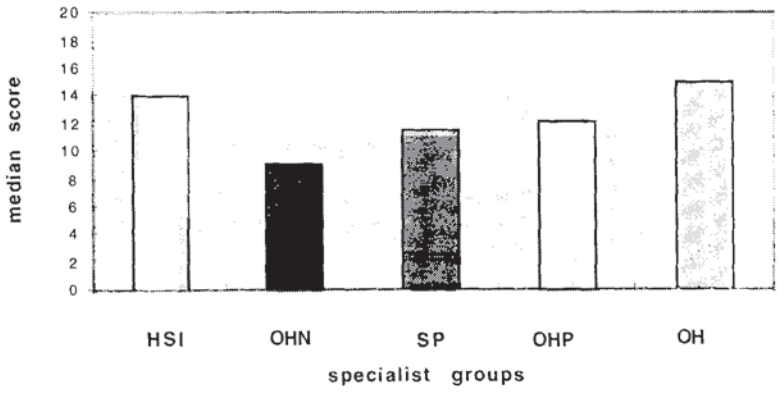


Figure 11.4 Process elicitation and task identification – median scores



Figures 11-5 and 11-6 below, illustrate that the hygienists' group performed best in the 'task characterisation' attributes listed in the matrix. This involved finding out more technical details about the identified process tasks (for example, substances used, their consumption, equipment used, task times).

Figure 11.5 Task characterisation

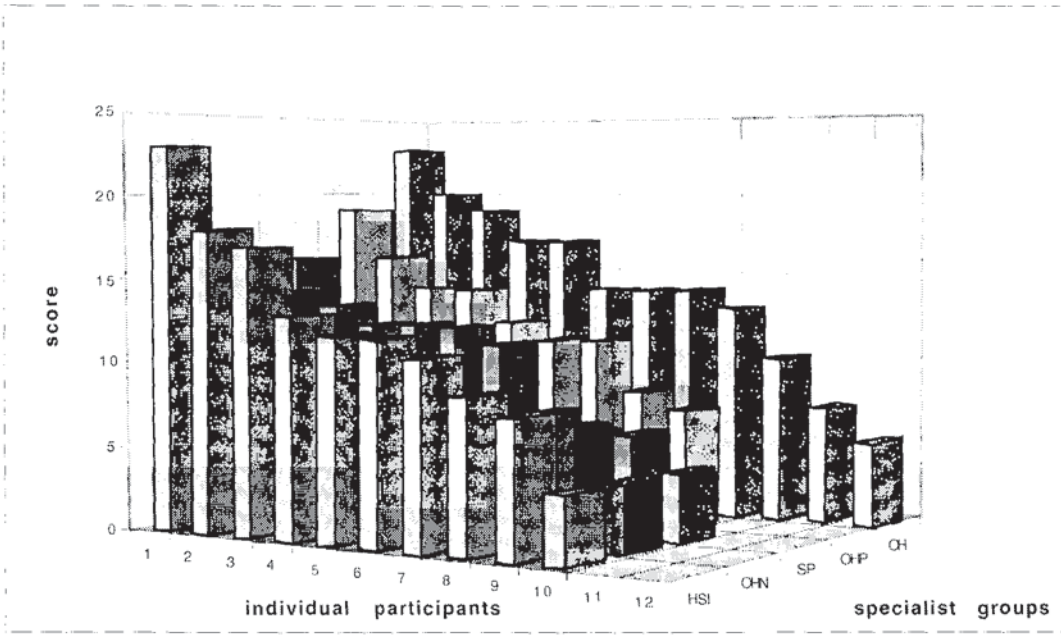
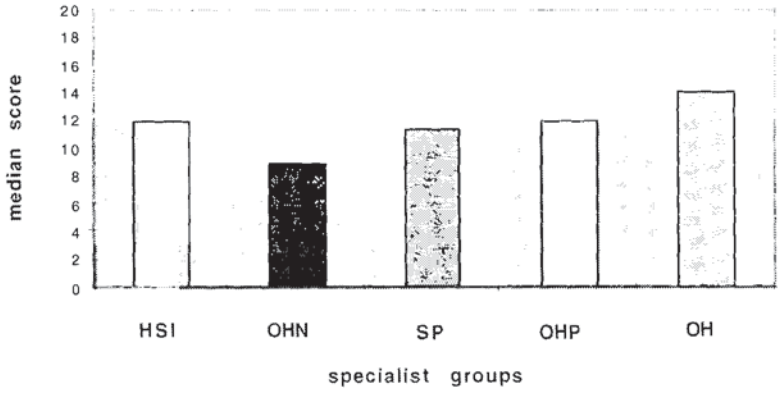


Figure 11.6 Task characterisation – median scores



Figures 11-7 and 11-8 show 'hazard identification and exposure assessment factors'. The occupational health physicians have the best median performance here. This division covered topics such as: identifying worker health effects;

staff turnover rate; substance data on inhalation and skin contact hazards from styrene; poor housekeeping; other health hazards such as lighting and noise as well as fire and safety hazards.

Figure 11.7 Hazard identification and exposure assessment

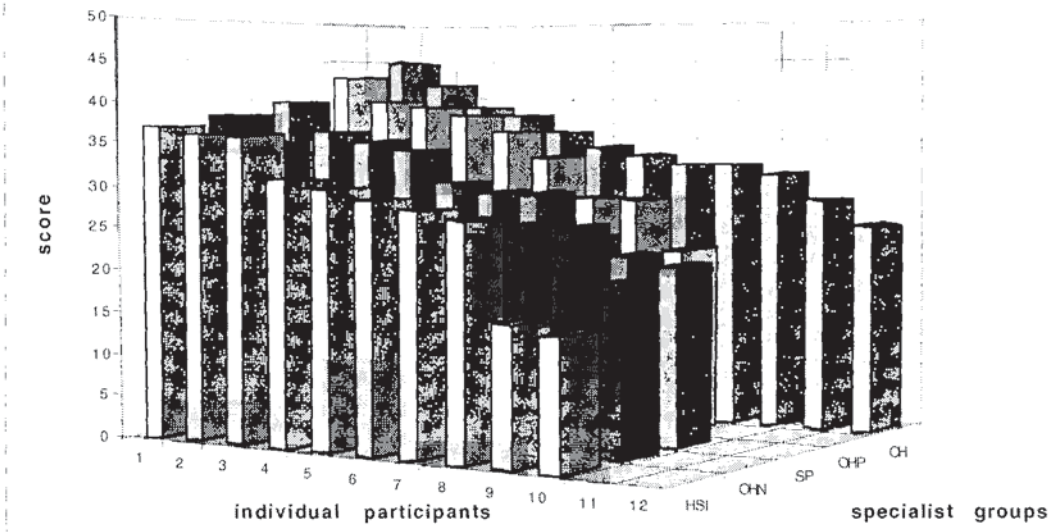
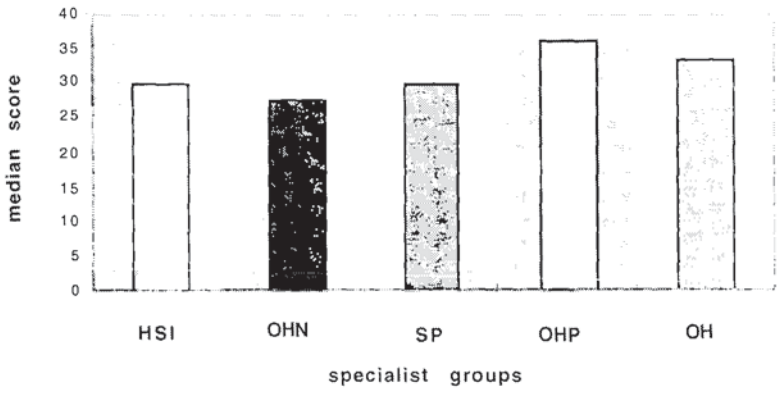


Figure 11.8 Hazard identification and exposure assessment – median scores



Figures 11-9 and 11-10 show performance in the 'Evaluation and audit of current control measures' division, which encompassed 'control measures' in a broad sense, not simply dealing with technical aspects such as provision of personal protective equipment and ventilation systems, but also procedural

measures such as health and safety audits/inspections; personal welfare facilities and the provision of information for the workforce. Further, strategic health and safety issues such as current HS policy and management organisation were included. The safety practitioners had the highest median score in this division of the matrix and consistently asked questions across the range of controls including current health and safety policy, provision of workforce health and safety information and training and questions to assess the attitude of the manager to health and safety in general.

Figure 11.9 Evaluation and audit of current control measures

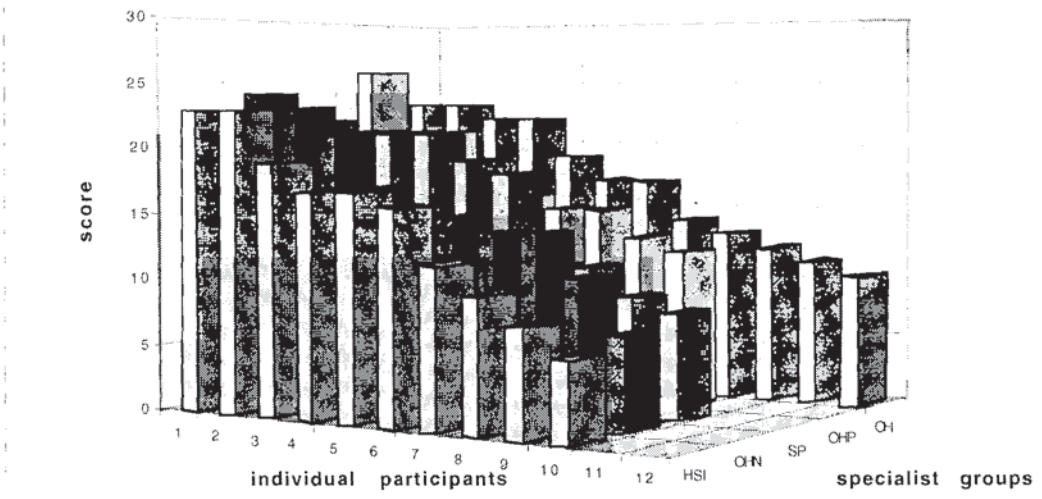
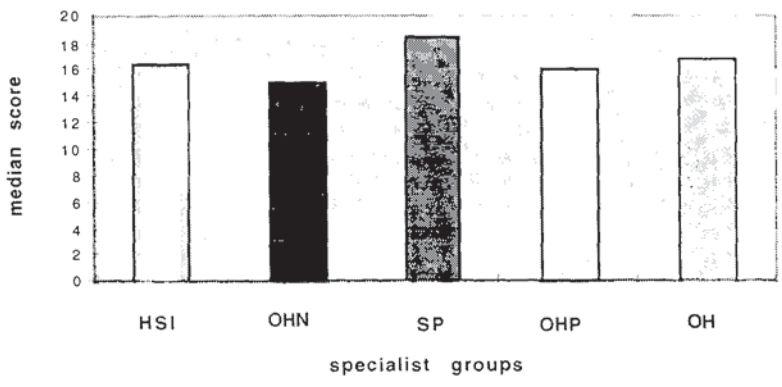


Figure 11.10 Evaluate/audit current controls – median scores



In the 'Identifying workgroups and task specialisation' division of the matrix the hygienists consistently elicited this information and this is presented in Table 11-23.

Table 11-23 Task specialisation

Occupational hygienists	83
Occupational health nurses	60
Occupational physicians	56
Trainee health and safety inspectors	50
Safety practitioners	40

The next division of the matrix is concerned with workgroup exposure profile and tolerability standards. Health risks from styrene inhalation and skin contact and glass fibre skin contact were most commonly thought to be significant. The fire risk from storage of resin drums in the work area was universally estimated to be intolerable. Figure 11-11 below illustrates the scores from the division of the matrix representing risk interpretation.

Figure 11.11 Compare workgroup exposure with tolerability standard

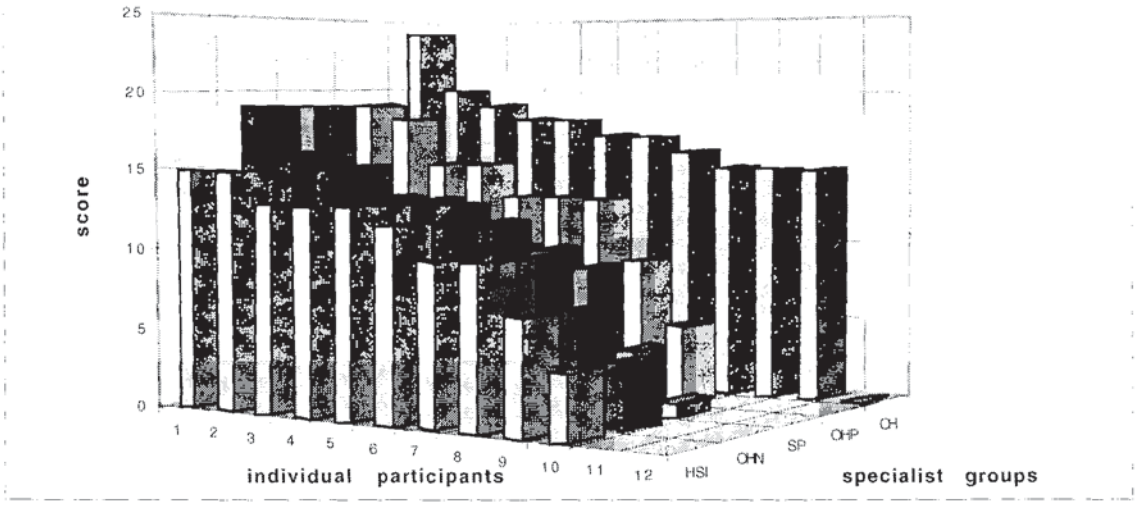
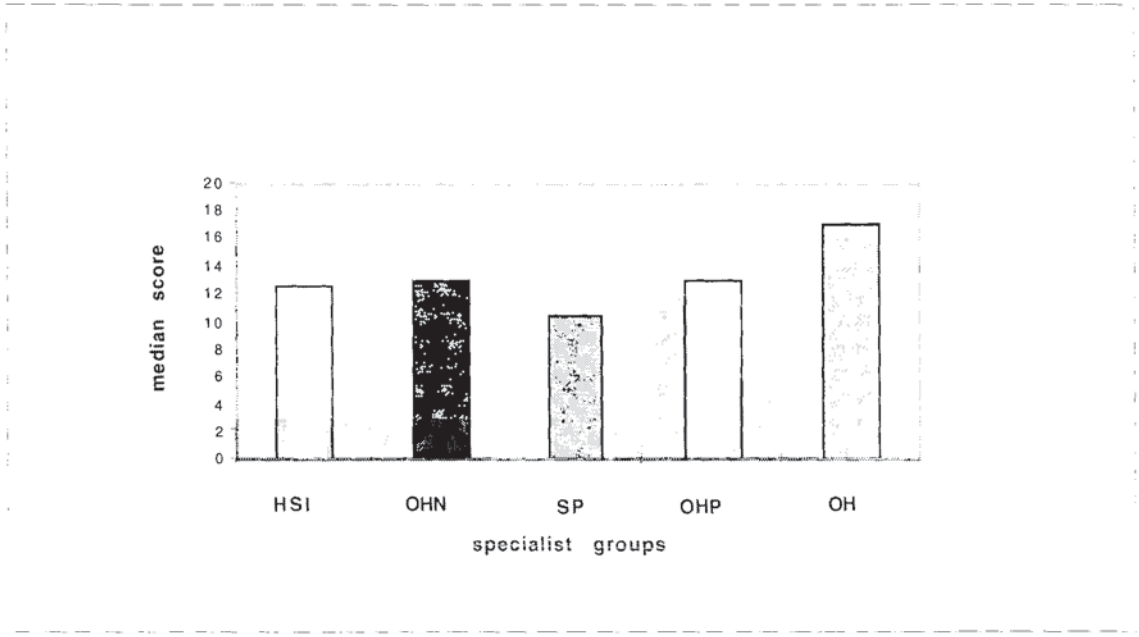


Figure 11.12 Workgroup exposure profile and standard – median scores



The occupational hygienists score highest in the 'Recommendations – specific controls' division of the matrix. This deals with recommended measures to be applied to workgroups to control particular risks. Thus, for the moulders for the health risk from styrene skin contact, one participant recommended: suitable gloves of a specified type to be determined by discussion with a glove

manufacturer and overalls for other skin protection. Others stated what was recommended on the HDS. It was mainly the OH group who identified the 'finisher' and followed up concern with control recommendations relating to moulding dust, noise and vibration risks.

Figure 11.13 Recommendations – specific controls

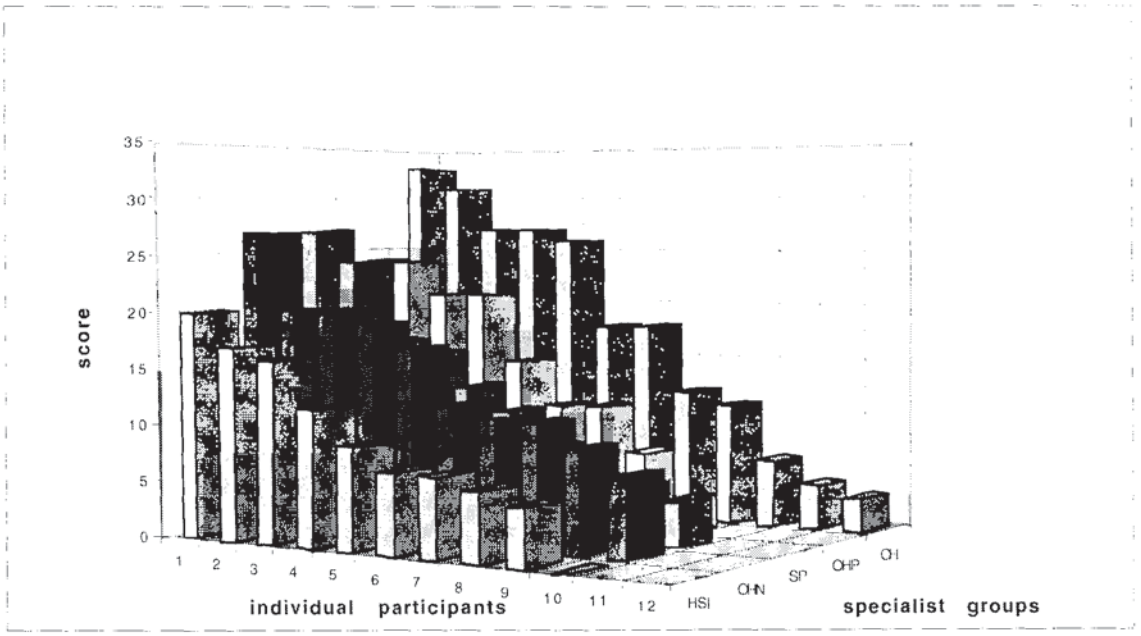
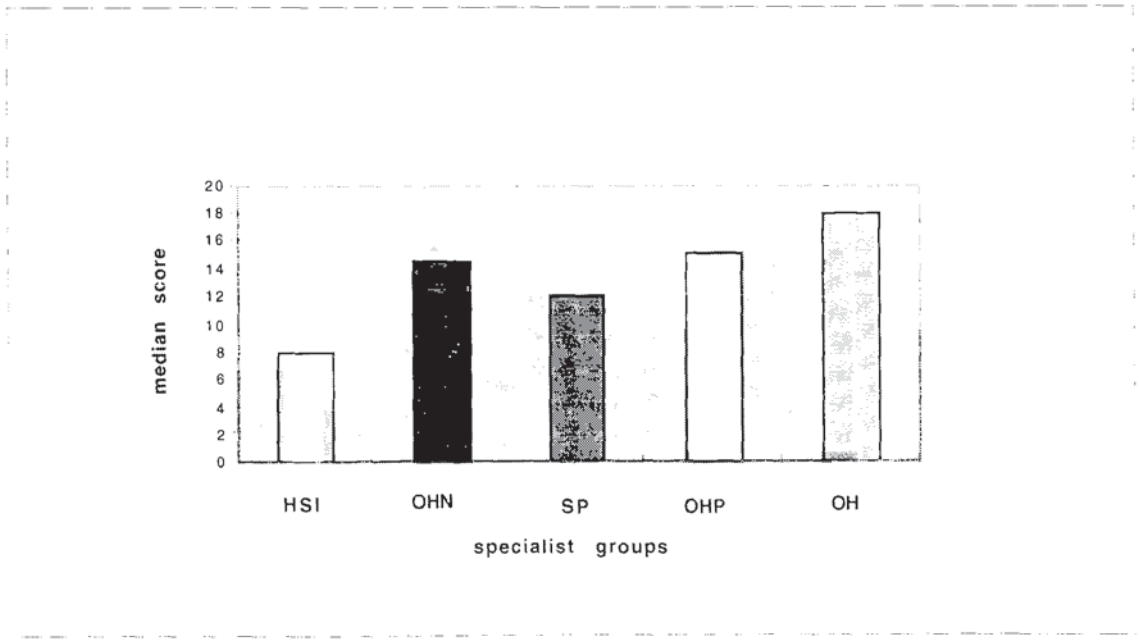


Figure 11.14 Recommendations – specific controls – median scores



The 'Recommendations – general controls' division is concerned with the more general controls that could be applied at the factory such as obtaining all hazard data sheets, improved worker HS training and carrying out necessary risk assessments. The OHN participants performed well, with the highest median score in this particular division of the matrix.

Figure 11.15 Recommendations – general controls

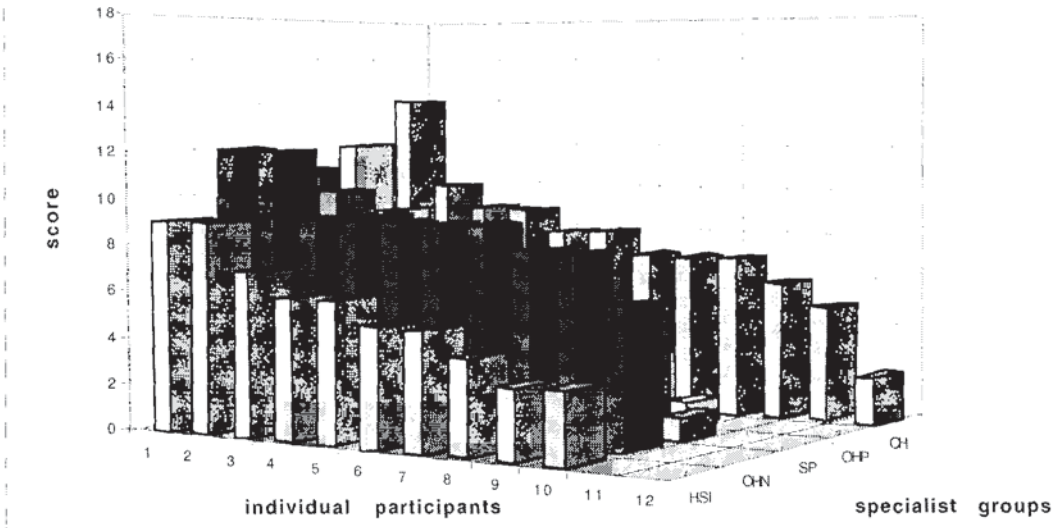
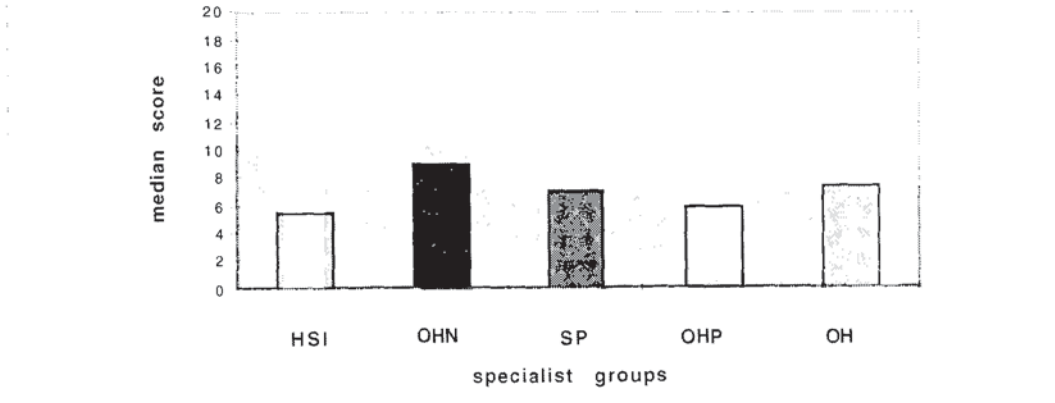


Figure 11.16 Recommendations – general controls – median scores



11.4.2 TOP TEN RANKINGS FOR SPECIALIST GROUPS

In the following series of charts (Figures 11-17 to 11-22) the same colour code is used as previously, ie, blue (Occupational hygienists); pink (Health and safety inspectors); red (Occupational health nurses); green (Safety practitioners) and yellow (Occupational health physicians).

Figure 11.17 Ranking scores for all participants on overall matrix

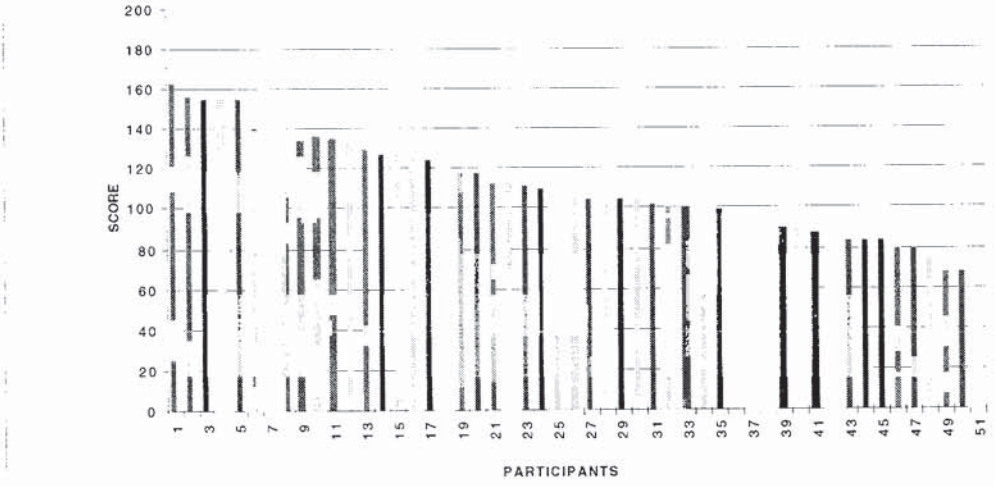


Figure 11.17 above shows the ranking of performance scores for all participants in the study across the overall matrix. It can be seen there is a preponderance of occupational hygienists at the high score end of the chart. This picture is seen again below.

Figure 11-18 shows that each group has a top-scoring representative in the 'Top ten' overall, but that the a majority are the hygienists. In Figure 11-19 the 'Top ten' scorers are made up almost exclusively of the hygienists and the trainee inspectors.

Figure 11.18 Ranking top ten – overall matrix

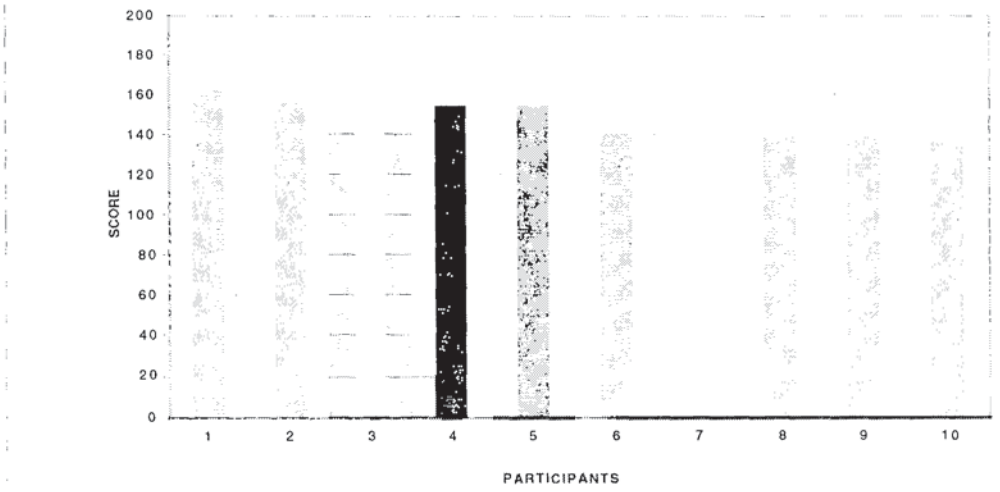


Figure 11.19 Top ten – Process elicitation/task identification

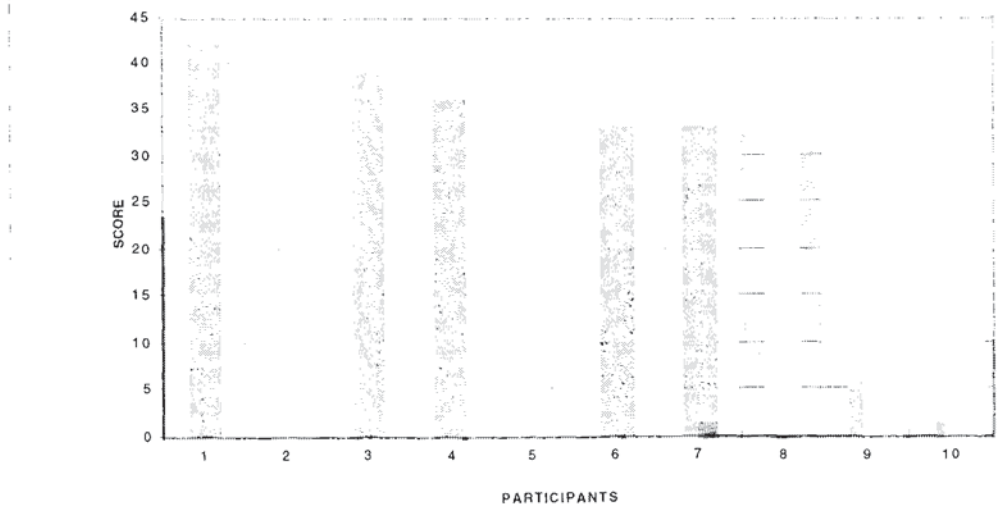


Figure 11.20 Top ten – hazard identification & exposure assessment

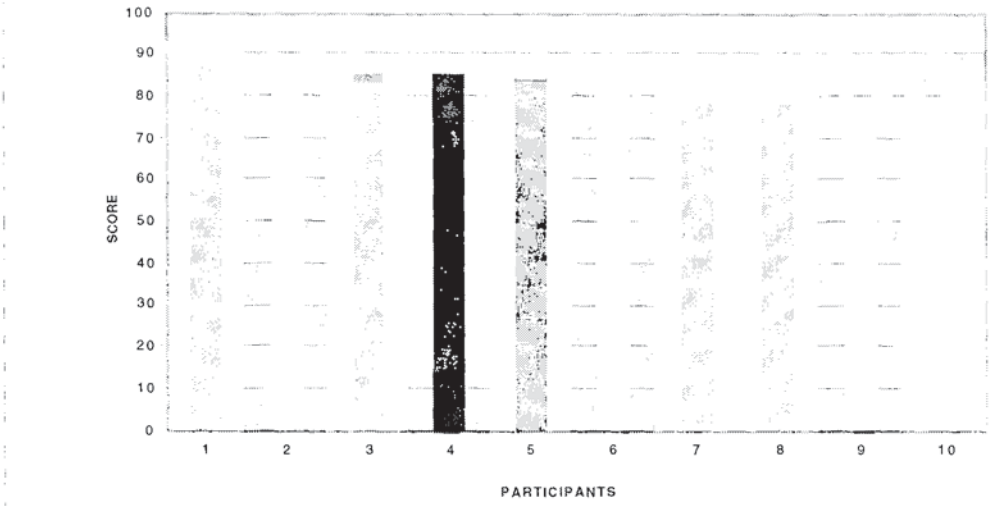


Figure 11.21 Top ten – recommendations – specific controls

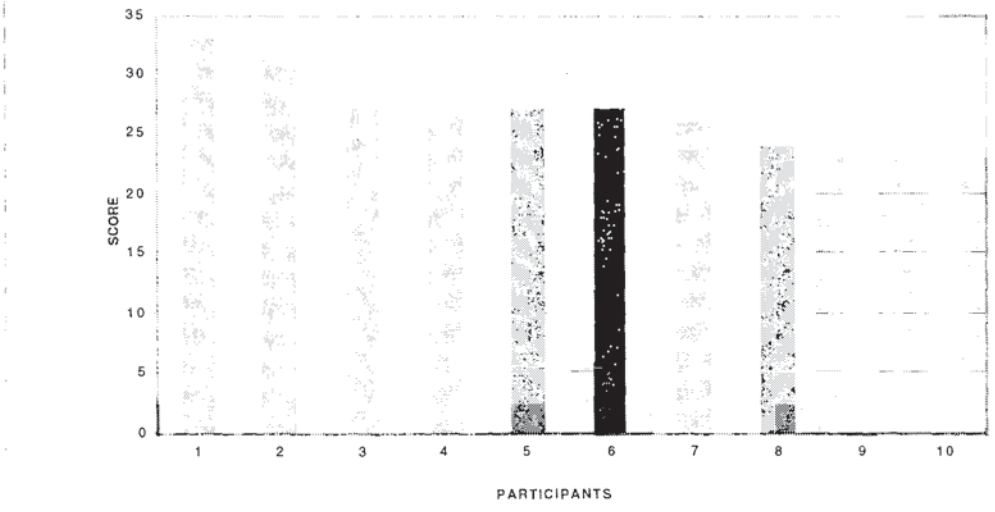
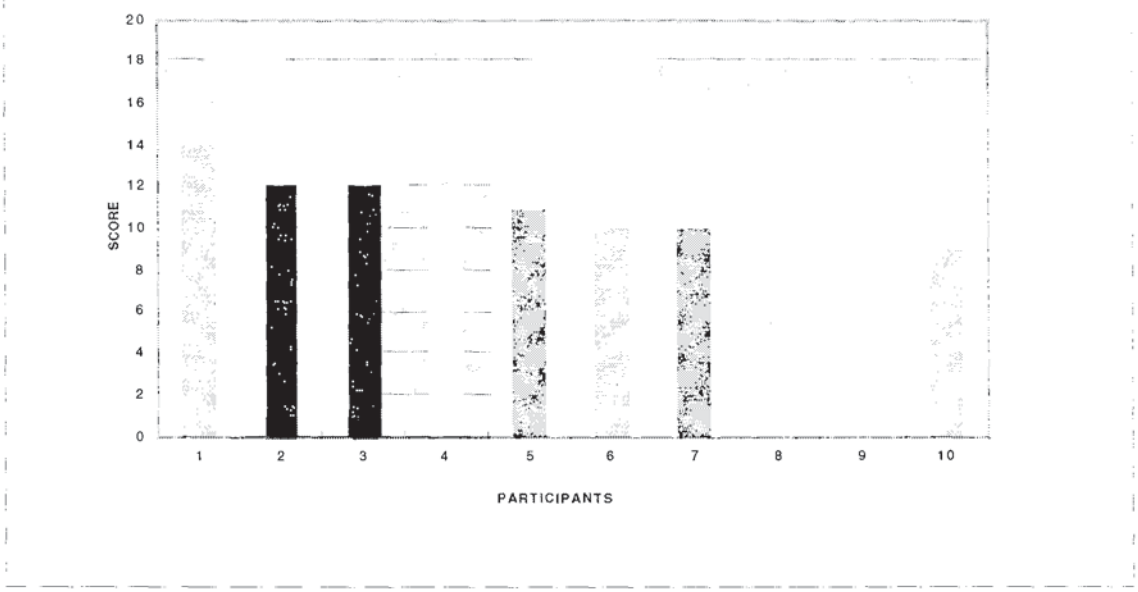


Figure 11.22 Top ten – Recommendations – general controls



11.4.3 COMPARISON OF SPECIALIST GROUPS IN SELECTED MATRIX CATEGORIES

The following discussion seeks to further explore some of the observed similarities and differences between the groups. Each Table presents a selected category from the matrix and shows the proportion of each group that scored (standardised as a percentage). The scores for the 'non-participating' hygienists are included in the percentages, which will tend to lower this group's scores. Individuals in the other groups also underperformed – one member of the safety practitioner group was noticeably very nervous and could be put in this category.

11.4.3.1 Process and task elicitation

There was a body of common questions, which were asked by most participants in the different groups. This was the case for tasks given a high profile in the videotape. The following Tables (11-24 and 11-25) show the proportion of participants explicitly identifying the polishing and repair activities (as examples of high profile tasks). From a total tape running time of

6 minutes, around 35 seconds (10%) was devoted to the polishing task. As can be seen all groups score highly in the identification of this task.

Table 11-24 Polishing task

[illegible]	[illegible]
Trainee health and safety inspectors	80
Occupational physicians	78
Occupational hygienists	75
Occupational health nurses	70
Safety practitioners	70

The repair task (21 seconds on videotape (6%)) was carried out on an occasional basis at the factory and this was usually a short duration activity carried out infrequently. Again, all groups scored highly in identifying this task (Table 11-25). A number of participants when examining this task, on being told that it involved a 'two-pack' filler, insisted on proceeding as if the preparation contained 'isocyanate' and what should be done based on this contingency. This was in spite of being told by the factory manager that it did not contain isocyanate. (Perhaps this could be viewed as a certain degree of scepticism about the knowledge of the manager.)

Table 11-25 Repair task

Repair task	[illegible]
Occupational physicians	100
Safety practitioners	80
Occupational health nurses	80
Trainee health and safety inspectors	80
Occupational hygienists	67

Non-visual process tasks

It is interesting to examine how different participants identified process tasks not shown in the videotape. As discussed above (11.3.2 and Table 11-4), the finishing process was carried out in a separate workshop by one operator. Proportionally, more of the OH group identified this unseen task.

Table 11-26 Finishing task

Occupational hygienists	75
Occupational physicians	44
Trainee health and safety inspectors	40
Occupational health nurses	30
Safety practitioners	20

11.4.3.2 Task characterisation

Apart from eliciting further technical details about tasks, this involved determining task times in the process cycle. (In a non-continuous process task frequency would also need to be determined.) The figures are relatively low but this is important knowledge as aptly put by one SP participant:

"If we are looking at health we are looking at exposure times."

The most probable explanation is that many participants made assumptions in believing that laying-up was the longest individual task carried out by the moulders.

Table 11-27 Task exposure times

Occupational physicians	44
Occupational health nurses	40
Occupational hygienists	33
Trainee health and safety inspectors	30
Safety practitioners	20

11.4.3.3 Hazard identification and exposure assessment

Most participants were interested in whether the manager had collected HDSs sheets for the substances in use.

Table 11-28 Hazard data sheets I

Identifies inadequate hazard data sheets	%
Safety practitioners	90
Occupational physicians	89
Occupational hygienists	83
Occupational health nurses	70
Trainee health and safety inspectors	70

Similarly, most participants in the groups identified the hazards from styrene and glass fibre.

Table 11-29 Styrene inhalation hazard

Identifies styrene inhalation hazard	%
Trainee health and safety inspectors	100
Occupational hygienists	100
Safety practitioners	100
Occupational health nurses	90
Occupational physicians	89

Table 11-30 Styrene skin contact hazard

Styrene skin contact hazard	%
Safety practitioners	100
Trainee health and safety inspectors	100
Occupational hygienists	100
Occupational health nurses	90
Occupational physicians	89

Table 11-31 Glass fibre as skin contact hazard

Identified as skin contact hazard	%
Occupational physicians	100
Occupational hygienists	100
Occupational health nurses	70
Safety practitioners	70
Trainee health and safety inspectors	50

Table 11-32 Ingestion hazard

Identified general ingestion hazard	%
Occupational physicians	56
Occupational health nurses	20
Safety practitioners	20
Trainee health and safety inspectors	10
Occupational hygienists	0

Table 11-32 indicates the numbers who asked if the manager had had any reports of health effects in workers:

Table 11-33 Worker health effects

Identified health effects in workers	%
Trainee health and safety inspectors	90
Occupational hygienists	83
Safety practitioners	80
Occupational physicians	78
Occupational health nurses	60

Most questions regarding smoking policy were posed from the viewpoint of resins and fire risk control rather than health education.

Table 11-34 Smoking policy

[illegible]	[illegible]
Trainee health and safety inspectors	80
Occupational physicians	78
Occupational health nurses	70
Safety practitioners	60
Occupational hygienists	58

11.4.3.4 Evaluation and audit of current control measures

Virtually all participants took an interest in general ventilation control at the factory:

Table 11-35 Current controls – ventilation

[illegible]	%
Occupational health nurses	100
Occupational hygienists	92
Occupational physicians	89
Trainee health and safety inspectors	80
Safety practitioners	70

However, this was less so with respect to identifying specifically local exhaust ventilation.

Table 11-36 Current controls – Local exhaust ventilation

[illegible]	%
Occupational hygienists	67
Occupational health nurses	50
Trainee health and safety inspectors	30
Safety practitioners	30
Occupational physicians	11

Similarly, with respect to PPE at the factory virtually all participants recognised that this protective measure was totally lacking.

Table 11-37 Current controls – General lack of personal protective equipment

General lack of PPE	%
Safety practitioners	100
Occupational health nurses	100
Occupational physicians	100
Trainee health and safety inspectors	100
Occupational hygienists	92

Table 11-38 Current controls – Previous risk assessment

Previous risk assessment	%
Occupational physicians	67
Occupational health nurses	60
Occupational hygienists	58
Trainee health and safety inspectors	50
Safety practitioners	40

The manager was often asked about any previous air monitoring surveys at the factory. Participants often recommended air monitoring as a basis for control measures. (Commonly, participants in the other groups regarded the occupational hygienists as the relevant experts to carry out this activity.)

Table 11-39 Current controls – Previous air contaminant monitoring

Air contaminant monitoring	%
Occupational hygienists	67
Occupational physicians	67
Safety practitioners	60
Trainee health and safety inspectors	40
Occupational health nurses	20

Table 11-40 Current controls – health surveillance

Health surveillance	%
Occupational physicians	78
Occupational health nurses	70
Safety practitioners	50
Occupational hygienists	42
Trainee health and safety inspectors	20

Safety practitioners were particularly interested in current levels of health and safety training and provision of information to the workforce (Table 11-41). The nurses and doctors asked more questions about current HS training on substance hazards and the process whilst the safety practitioners were more concerned with health and safety training in general.

Table 11-41 Current controls – HS training

Provision of worker HS training	%
Safety practitioners	70
Occupational hygienists	58
Occupational physicians	56
Occupational health nurses	40
Trainee health and safety inspectors	40

Table 11-42 Current controls – Provision of worker HS information

Provision of worker HS information	%
Safety practitioners	70
Occupational hygienists	58
Occupational physicians	56
Occupational health nurses	40
Trainee health and safety inspectors	40

The occupational health practitioners (nurses and physicians) were more inclined to ask about welfare aspects such as eating and drinking together with washing and toilet facilities.

Table 11-43 Current controls – Eating and drinking facilities

Eating and drinking facilities	%
Occupational physicians	75
Occupational health nurses	70
Safety practitioners	40
Trainee health and safety inspectors	30
Occupational hygienists	25

Table 11-44 Current controls – Washing and toilet facilities

Washing and toilet facilities	%
Occupational health nurses	60
Occupational hygienists	42
Occupational physicians	33
Trainee health and safety inspectors	30
Safety practitioners	20

Also, occupational physicians and nurses were most inclined to determine the extent of the factory's provision of first aid facilities.

Table 11-45 Current controls – First aid provision

First aid provision	%
Occupational physicians	44
Occupational health nurses	40
Safety practitioners	30
Occupational hygienists	25
Trainee health and safety inspectors	10

Further, Table 11-48 illustrates the interest taken particularly by the inspectors in asking specifically if the manager had *read* the HDS! This demonstrated the

inspectors operating as interrogators as in their normal inspection mode. Other groups were more restrained in finding out the manager's attitude to health and safety matters (Table 11-49).

Table 11-46 Current controls - HS audits/inspections

HS Audits/inspections	%
Safety practitioners	50
Occupational physicians	44
Occupational health nurses	40
Occupational hygienists	33
Trainee health and safety inspectors	30

Table 11-47 Current controls - management HS training/information

Management HS training/info	%
Occupational hygienists	83
Occupational physicians	78
Occupational health nurses	60
Safety practitioners	50
Trainee health and safety inspectors	50

Table 11-48 Hazard data sheets II

Use of hazard data sheets	%
Trainee health and safety inspectors	50
Occupational physicians	22
Safety practitioners	10
Occupational hygienists	0
Occupational health nurses	0

Table 11-49 Manager's attitude to health and safety

[illegible]	[illegible]
Safety practitioners	70
Trainee health and safety inspectors	50
Occupational physicians	33
Occupational hygienists	25
Occupational health nurses	20

11.4.3.5 Task specialisation

Whether the workers in the factory specialise in carrying out one particular task or whether they each carry out a range of tasks for a shorter period of time. This is an important question in the identification of the extent of exposure and the evaluation of risk. As can be seen most of the occupational hygienist scored with respect to this attribute. In the factory questions relating to specialisation allowed identification of the moulder and finisher workgroups.

Table 11-50 Task specialisation

[illegible]	[illegible]
Occupational hygienists	83
Occupational health nurses	60
Occupational physicians	56
Trainee health and safety inspectors	50
Safety practitioners	40

11.4.3.6 Conclusion on tolerability of risk

Risks from styrene inhalation and skin contact, glass fibre skin contact, GF-containing dust in the finishing shop were all regarded as intolerable exposures. Mostly the hygienists commented that in they thought moulders were probably exposed in excess of the MEL value. Also, the hygienists systematically followed up exposure of the finisher to sanding dust (and noise and vibration) by questioning the manager.

Table 11-51 Moulders – styrene inhalation risk

Moulders – styrene inhalation risk	%
Occupational hygienists	100
Trainee health and safety inspectors	90
Safety practitioners	80
Occupational health nurses	80
Occupational physicians	78

Table 11-52 Moulders – Styrene skin contact risk

Moulders – styrene skin contact risk	%
Occupational hygienists	100
Safety practitioners	90
Trainee health and safety inspectors	80
Occupational health nurses	80
Occupational physicians	78

Table 11-53 Moulders – GF skin contact risk

Moulders – GF skin contact risk	%
Occupational physicians	100
Occupational hygienists	100
Safety practitioners	60
Occupational health nurses	60
Trainee health and safety inspectors	50

Table 11-54 Finisher – dust inhalation risk

Finisher – dust inhalation risk	%
Occupational hygienists	42
Trainee health and safety inspectors	0
Safety practitioners	0
Occupational health nurses	0
Occupational physicians	0

11.4.3.7 Recommendations

The safety practitioners, occupational hygienists and the physicians in particular recommended exposure of the moulders be measured by styrene air monitoring. Further, the occupational health nurses and physicians showed a strong preference for recommending worker health surveillance.

Table 11-55 Recommendations – Styrene air monitoring

Styrene air monitoring	%
Safety practitioners	90
Occupational hygienists	75
Occupational physicians	67
Occupational health nurses	50
Trainee health and safety inspectors	40

Table 11-56 Recommendations – Health surveillance

Worker health surveillance	%
Occupational health nurses	50
Occupational physicians	44
Occupational hygienists	33
Trainee health and safety inspectors	20
Safety practitioners	20

Table 11-57 Recommendations – Hazard data sheets

Obtain material hazard data sheets	%
Occupational health nurses	80
Occupational hygienists	75
Trainee health and safety inspectors	70
Occupational physicians	56
Safety practitioners	50

Table 11-58 Recommendations - Improved resin drum labelling

Improved resin drum labelling	%
Occupational health nurses	80
Occupational hygienists	58
Occupational physicians	44
Safety practitioners	20
Trainee health and safety inspectors	10

Table 11-59 Recommendations - PPE in general

Personal protective equipment	%
Safety practitioners	100
Occupational health nurses	100
Trainee health and safety inspectors	90
Occupational physicians	89
Occupational hygienists	83

Table 11-60 Recommendations - Worker health and safety training

Workers - HS training needed	%
Safety practitioners	80
Occupational health nurses	80
Occupational hygienists	75
Trainee health and safety inspectors	50
Occupational physicians	33

11.4.3.8 Other health hazards

The occupational health physicians were particularly interested in eliciting information on other health hazards such as noise and lighting.

Table 11-61 Noise hazard identification

[illegible]	[illegible]
Occupational physicians	67
Occupational hygienists	67
Safety practitioners	50
Trainee health and safety inspectors	50
Occupational health nurses	30

Table 11-62 Lighting hazard identification

[illegible]	[illegible]
Occupational physicians	89
Occupational hygienists	75
Safety practitioners	70
Occupational health nurses	70
Trainee health and safety inspectors	40

11.4.3.9 Safety hazards

The fire hazard presented by the storage of high quantities of highly flammable liquids stored in drums in the workplace provoked at lot of questioning by individuals. Virtually all participants in the groups identified the serious fire risk arising from the storage of excessive amount of styrene resin (a highly flammable liquid) at the premises. The situation was thought to constitute a highly dangerous fire and explosion risk. As a consequence of this, improved resin storage (in a separate secure zone away from the factory) was recommended (Table 11-64).

Table 11-63 Intolerable fire risk (excessive flammable liquids)

Storage of highly flammable liquids	%
Occupational health nurses	100
Safety practitioners	90
Trainee health and safety inspectors	90
Occupational physicians	89
Occupational hygienists	83

Table 11-64 New resin drum storage area

Resin drum storage area needed	%
Occupational physicians	78
Trainee health and safety inspectors	70
Occupational health nurses	70
Occupational hygienists	67
Safety practitioners	50

The safety practitioners most commonly followed this up with numerous supplementary detailed questions about general fire controls and the lack of adequate precautions at the factory. (For example, Participant SP8 asked a further eight questions on fire.)

It is likely that specialists like to ask questions about subject with which they feel most familiar. This group commonly took a wider view of the workplace than requested by the briefing. As well as fire, first-aid provision, manual handling activities and fork-lift truck (FLT) hazards each featured prominently in their queries. Safety practitioners were more inclined to ask about the structure of the company, its health and safety organisation and whether the manager had any training in health and safety.

Table 11-65 Health and safety policy

Health and safety policy	%
Safety practitioners	40
Occupational hygienists	25
Occupational physicians	22
Occupational health nurses	10
Trainee health and safety inspectors	10

Table 11-66 Management HS training and information

Manager's HS training/information	%
Safety practitioners	40
Trainee health and safety inspectors	30
Occupational health nurses	20
Occupational physicians	17
Occupational hygienists	8

11.5 CONCLUSIONS

This section contains conclusions regarding the videotape KE study findings, whilst Chapter Twelve has the conclusions regarding this methodology. There is a final overview which presents summary conclusions and recommendations for the whole research project in Chapter Thirteen.

11.5.1 ALL PARTICIPANT GROUPS

1. **Study of the consultation transcripts gave useful insight into the approach of participants to the HSRA exercise.**

   The videotape provided a rich tableaux of information on hazards and apparently uncontrolled risks at the factory. The experience of interviewing the manager gave an impression of the 'safety culture' at the factory. The issues raised in the consultations resulted in the development of a composite matrix with 137 categories. These issues arose as questions,

comments, conclusions and recommendations following the request to study participants to carry out a 'health risk assessment' and make 'recommendations for action ' at the factory.

2. **Participants identified a wide range of health, safety and strategic management issues.**

   Participants identified a wide range of issues covering both health and safety. The technical aspects of health risk assessment, where although the emphasis was on harmful substances, lighting, noise, vibration, manual handling and repetitive strain hazards arose. In terms of 'safety' issues such as fire, electrical, fork-lift truck and general workplace hazards caused by poor housekeeping and maintenance came up in the discussions. As well as the technical aspects of risk assessment, many participants were interested in strategic health and safety policy within the company.

3. **There was near universal recognition of fire as the top priority risk at the factory.**

   The major risk at the factory was perceived to be from fire arising from resin drum storage. Virtually every participant in each specialist group mentioned this, commenting to the manager that action was needed. This demonstrates that participants were willing to ignore their brief if they thought the issue was sufficiently important. It is welcome that health and safety specialists of each professional group, applied core knowledge and pointed out such a risk in spite of their reason for visiting the factory.

4. **Some participants gave inappropriate attention to peripheral issues.**

   Having drawn sufficient attention to this fire risk, some participants went on unnecessarily to audit, in some detail, the company's fire precautions. This may have been a matter of participants being happier dwelling on familiar subjects, rather than what was requested. Fire, fork-lift truck and electrical issues were often covered in inappropriate detail.

5. **Most participants recognised the principal health risks at the factory and this was acknowledged in their conclusions and recommendations.**

The vast majority of participants considered that there were significant health risks at the factory, arising from principally inhalation of styrene vapour and skin contact with styrene-based resin and glass fibre sheet. A minority were concerned about inhalation exposure to glass fibre particles. Those participants who identified and considered the finisher's work concluded that although he was exposed high dust levels, on the evidence they had, the health risk was adequately controlled.

6. **The majority of participants recognised the lack of management control of health and safety at the factory and this was reflected in many cases in their recommendations.**

   The lack of management interest in, and control of, health and safety at the factory was universally recognised by participants in the study. That this was the case, was to some extent indicated in the videotape, but it was also deduced/confirmed from questioning the manager with his relaxed attitude to health and safety. Many questioned the manager to determine such issues as to whether there was a health and safety policy and if anyone had received adequate training, subsequently making appropriate recommendations.

7. **As well as considering the core health risk assessment aspects, each specialist group demonstrated its own idiosyncrasies in approaching the exercise.**

   The safety practitioners tended to ask questions about HS policy, organisation and strategy, whilst the occupational health physicians and occupational health nurses were particularly interested in health surveillance, first aid and welfare provision. Interestingly, some nurses brought up the subject of job satisfaction and task enlargement with concern for workers' mental health.

   The health and safety inspectors were occasionally too overbearing and forceful than was appropriate for an 'invited' visitor. However, this was less so than in the pilot study, after which the protocol briefing was changed to explicitly rule out the assessor having any enforcement powers.

Nevertheless, often with this group the style was 'interrogatory' as has been discussed above.

Overall, in contrast, the occupational hygienists tended to focus more closely on the health risk assessment. They were doggedly persistent in eliciting the whole production process and identifying hazards and sources of exposure from the substances in use. They appeared to be most comfortable with the chemical aspects of the GRP moulding process and they were particularly interested in air contaminant monitoring, either identifying whether this had already been carried out at the factory or recommending action that this should be done. Bearing in mind the constraints of the experimental set-up, the hygienists recommended the most detailed and specific applied process control action, following the walk-through survey.

8. **The combination of the videotape and the role-play was very effective at getting participants involved with the factory and its problems.**

The 'involvement' with the manager made some participants irritated, some concerned and others philosophical and unsurprised. Nevertheless, many expressed the view that the combination of the realistic videotape and the role-play had made the factory and its problems *alive*. This was the case with some who were initially a little nervous and apprehensive and subsequently very much 'got into' the role-play.

9. **Participants were aware of the limits of their expertise.**

All believed that they had sufficient knowledge and skills to attempt the requested walk-through HSRA survey. However, carrying out air monitoring and the application of ventilation controls was seen to be the province of the occupational hygienist. Some participants did comment that management could carry out basic health surveillance ie, look at peoples' hand as a check for dermatitis. Similarly, some mentioned that simple air monitoring instruments are available which management could be trained to use. One carefully phrased a request for an air monitoring survey to get the best use of a consultant. There were some examples of

participants probably being too cautious about how far they could progress in the exercise.

11.5.2 CLASSIFICATION OF HYGIENISTS' TRANSCRIPT FRAGMENTS

1. **A wide range of variation in both quality and quantity of transcript data can be observed in the HSRA classification tables.**

2. **The classification of the transcript fragments gave some cross-validation with the performance matrix.**

   Occupational hygienists who had the highest frequency of (nominally) 'no comment', in the fragment categorisation correlated with those who had the lowest scores on the matrix.

11.5.3 PERFORMANCE MATRIX

Summary conclusions are drawn about the performance of the specialist groups as evaluated by the matrix. (The median value, as before, is used as an indicator of group performance.)

11.5.3.1 Occupational hygienists

1. **As a professional group the occupational hygienists scored highest on the overall matrix (although there was a wide variation in individual performance within this group).**

2. **As a professional group the occupational hygienists scored highest in five from eight matrix sub-divisions.**

   These were namely: 'process elicitation and task identification'; 'task characterisation'; 'identifying workgroups and task specialisation' 'comparing workgroup exposure profile with exposure standard' and 'recommendations for applying specific controls'.

3. **When ranking all participants on the overall matrix, six from the top ten scorers were hygienists.**

4. **In each sub-division of the matrix a Hygienist had the highest individual score.**

The highest scoring hygienists showed a consistent and single-minded approach to eliciting the process and finding out about tasks. They also scored well when recommending specific controls to the process and these tended to be detailed and practicable.

11.5.3.2 Occupational health physicians

As a professional group, the occupational health physicians scored highest in the 'hazard identification and exposure assessment' sub-division.

This group performed well in the above, which represents the diagnostic aspects of the exercise. They scored less well on the application of specific control measures.

11.5.3.3 Safety practitioners

The safety practitioners as a professional group had the best performance in the 'evaluation and audit of current control measures' sub-division.

This group did not perform well in finding out about processes and tasks. They tended to be better at eliciting and examining information on safety hazards and health and safety management at the company.

11.5.3.4 Occupational health nurses

The occupational health nurses scored highest across the professional groups in the 'recommendations - application of general controls' subdivision.

This group tended to ask about welfare facilities, first-aid and health surveillance. As a group they did not perform so well in finding out about the process and tasks.

11.5.3.5 Trainee health and safety inspectors

As a professional group, the trainee health and safety inspectors were a close second in the 'process elicitation and task identification' and 'task characterisation' sub-divsion of the matrix.

This group were skilled in finding out about the process and tasks. In other aspects of HSRA they were not so clear as to what questions to ask. Some tended to give more generic recommendations on controls.

12.

Knowledge elicitation: risk assessment videotape case study – discussion of methodology

12.1 INTRODUCTION

This Chapter will review the methodological aspects of the videotape method as described and applied in Chapters Ten and Eleven. Possible wider application and further development of the technique will also be discussed.

The Chapter is divided into the following sections:

1. pre-consultation and briefing
2. the videotape
3. interviewing the factory manager
4. analysis of audio-tape transcripts
5. general aspects
6. development and application of the technique

12.2 PRE-VISIT KNOWLEDGE AND CONSULTATION BRIEFING

12.2.1 PRE-VISIT KNOWLEDGE

Participants were not given any information about the exercise or the content of the videotape before the consultation session. Here lies a contrast with real-life situations where visitors normally would have a chance to brief themselves on the basics of an unfamiliar industrial process before a visit. An imminent visitor may telephone beforehand in order to gain a feeling for the general situation, processes, substances, tasks and numbers of people exposed and so on. In this study this option was not available but with a re-designed protocol this aspect could be incorporated in future although this would probably distort subsequent results.

12.2.2 PRE-CONSULTATION BRIEFING

The oral and written briefings were imperative since it was vital that participants clearly understood what they were required to do. The pre-consultation briefing needed to unambiguously define the status of the 'assessor' (ie, whether they were an independent person, an expert specialist or an enforcement inspector). In the pilot study, some of the inspector trainees noticeably tried to hold on to their normal inspection role (and presumably enforcement powers). Therefore, in the amended briefing used in the main study , it was made clear that they were expected to undertake the HSRA as an "independent person without formal inspection powers". Even so some characteristics of this group's approach could be linked to their normal occupational role.

12.3 THE VIDEOTAPE

12.3.1 GENERAL ASPECTS

The method was developed as a way of studying the approach of a group of participants to the same risk assessment problem. Introducing the case-study situation by videotape represented a reproducible way of presenting initial information. The videotape provided an impressionistic, realistic and dynamic medium by which people, activities and tasks could be viewed continuously in

simulated real-time. Overall, this gave a more three dimensional perspective than possible alternative approaches to information provision such as written scenarios, still photographs or 35 mm slide shows.

12.3.2 THE CONTENT OF THE VIDEOTAPE

The temporal sequence of the videotape as a tour around the factory and its processes influenced the nature of the problem-solving exercise. For example, participants saw the polishing operator before they saw the laying-up work. Therefore, it was likely that they would ask questions about polishing before they asked about laying-up and so on. The videotape did not present the GRP process in a comprehensive and logical sequence - it highlighted some important tasks and completely omitted others. The order of the tasks shown did not follow the logical progress of the manufacturing process. Part of the exercise was for participants to assemble discrete tasks into the production process. One hygienist participant commented on this:

> "I find it quite difficult to do; its a bit disjointed really - you are trying to remember things in not a particular order." (OH12)

The tape is a pre-determined view of the workplace not only in terms of the sequence of activities shown, but also in terms of the emphasis (ie, the time) given to different aspects (pages 205 and 206). The polisher is the first worker visualised and the repair task worker also has a high profile. It is reasonable to assume that the more attention an activity is given in the tape, the more likely one is to have questions concerning it.

Sometimes, it was thought, in this case erroneously, by participants, that the more time a task was given on the tape, the more important it was to the overall HSRA exercise. In a real-life factory process description conducted by a communicative manager, the visitor might reasonably expect a logical tour following the identifiable steps of the process with appropriate time spent at each stage. This artefact may have increased the difficulty of the set risk assessment exercise.

Using a video-camera, it is difficult to simulate a glance at a point of interest. Looking at the factory roof resulted in a significant sequence in the tape (35

seconds) where the picture moves across the ceiling of the work area. Not surprisingly, it was common at this point in the consultation, to have a series of questions concerning the roof of the factory. These were mainly concerned with ventilation, lighting and fire risk. This demonstrates that using a videotape is not a neutral stimulus and any tape may distort the interpretation and approach of the participant viewer to the scenario presented.

12.4 INTERVIEWING THE FACTORY 'MANAGER'

12.4.1 THE ROLE OF THE MANAGER

The author role-plays the factory manager and originally the role was intended to be mainly one dimensional in that the 'manager' was to be a passive supplier of technical or related information when asked appropriate questions. For example, 'What is that worker doing?' or 'What is that substance he is using for that task?' 'What is that process called?' Each of these are closed questions and the manager had no difficulty dealing with them. On the other hand some questions were more problematic. For example, 'Can you describe the whole process to me?' or 'What is your view on health and safety at this factory?' It became apparent very soon that the manager would have other dimensions if the role-play was to be successful. The role was based (as far as possible) on the attitude and general standpoint of the manager at the actual factory.

The possibility of using the genuine factory manager for the role adopted by the author was indeed considered, but discounted due the requirement for a largely standard, objective commentary of the work process. This called into question the ability of the manager to maintain objectivity when asked repeatedly (by a series of participants) about unidentified hazards and uncontrolled risks; an issue of familiarity in addition to more fundamental considerations of time and availability.

12.4.2 RELATIONSHIP BETWEEN THE PARTICIPANT AND MANAGER

In the scenario the visitor to the premises does not have to develop a 'real' relationship with the manager - he does not have to be restrained or even

polite. This is a disadvantage since it detracts from the realism of the method. In the real world the consultant or visitor would require a reasonable interaction to function effectively. Some of the trainee inspector assessors were too forceful with their inquisitorial style especially as 'invited visitors' to the factory. Furthermore, within the context of the exercise the assessor can recommend 'ideal' control measures with no actual responsibility for the true cost. Although, were the technique to be used in a training or examination context, these aspects could be queried.

This is an often heard complaint about 'consultants' in the real world, as Hygienist A in the exploratory interviews put it:

> "Yes I am - very cynical [about consultants] - licence to print money - and they will not achieve anything! They are engendering the climate almost deliberately that you must have it measured! If I generate a concentration C at this point here on the bench it does not require much knowledge to know that as we move away a 100 metres away there will be nothing but you will have people asking people doing processes metres and metres away doing sampling to check the spread - what for?"

In a real visit, one would hope that the risk assessor would develop a relationship and project his credibility with the manager. As discussed in Chapter Eleven, it is helpful for the assessor to be aware of the manager's attitude to health and safety and other *management* issues. It is also important to know the manager's view on possible control measures, which the assessor may raise in discussion. (In real life this particular manager did not believe that he had many health and safety problems at his factory apart from the fire risk about which he was concerned.)

Impressions are also formed from other clues, for example, one hygienist participant commented:

> "From a look at the company they are not going to be able to afford anything high faluting."

12.4.3 REPRODUCIBILITY OF THE MANAGER'S RESPONSES TO QUESTIONS

The factory manager had to be careful to give the same or similar responses to essentially the same question from different participants. Otherwise, this

would have introduced bias in the direction of consultations. (It was also inevitable that different participants would use a different form of words to ask essentially the same question.)

It was difficult to simulate a genuine manager's description of their industrial process. The description of the GRP process was that elicited from the real manager by the author during a visit to the factory. However, it could be argued, that to some extent this represents a 'sanitised' version since it has already gone through the mind of someone qualified and experienced in health and safety (ie, the author).

Occasionally, particularly in the pilot study, the manager gave excessive information in response to a question. This biased the subsequent direction of the consultations concerned. For example, one person asked: 'What chemicals are being used in the process?' In response to this the manager inadvertently and inappropriately gave a full process description instead of simply giving the information requested. It is necessary to guard against this contingency.

12.4.4 LIMITS OF THE MANAGER'S KNOWLEDGE

Sometimes, a participant cast the factory manager/author in the role of a health and safety resource when asking for information or an opinion on some aspect of the problem. During the consultation only the factory manager with his limited knowledge and experience in health and safety was available to answer questions.

12.4.5 WORKERS UNAVAILABLE FOR INTERVIEW

In a real scenario other people including shopfloor workers would normally be available as information providers. However, in the consultations only the factory manager was available. Questions to workers can elicit the way the work is actually carried out as opposed to the formal specification in a work method. (Sometimes in real life, management are only poorly aware of how work is actually carried out.) Hence, it was not surprising that participants often wanted to interview the workers themselves about their tasks, possible health effects, absence from work and other topics. In the development of the

case study the author did interview workers at the factory and where appropriate, attempted to relay relevant information to participants (albeit through the manager).

12.5 DEVELOPMENT OF THE ANALYTICAL MATRIX

Various attempts were made to develop a usable matrix in order to systematically analyse the content of transcripts. Participants had relatively wide freedom of action in the consultation and this produced considerable variation in approaches to the exercise. Over a period of time, several analytical matrices were produced and in each case these tended to develop a common problem ie, they became too large to be of practical use.

A task analysis matrix was produced which focused primarily on the manufacturing process. This became too large and unwieldy to use and it became difficult to examine the content of the consultations. Using this, a quantitative analysis of some transcripts was attempted. However, this was not successful as it was often possible to justify placing questions or comments in different categories. The problem arose as to where to add the tally. Participants tended to interchange between general and specific questions and it was often difficult to determine in a particular case, which meaning was intended ie, whether the query was concerned with a specific task or was addressed to the global process. By representing fragments of transcripts as tally numbers in the different categories, some of the richness of the original data was lost.

Finally, a classification and a matrix were developed, each with a different purpose. The classification was designed for content analysis of the original transcripts, whilst keeping the original narrative of the consultations.

The matrix allowed the computation of a performance score for each transcript and this was developed as follows:

1. Identification of categories was based on HSRA Model B and the content of the composite answer of participants to the risk assessment exercise.

2. Weightings assigned by the author to each category

3. Analysis of the tape transcripts.

12.6 VIDEOTAPE SIMULATION AND REAL FACTORY VISITS

There would be some disadvantages with real factory visits:

- first, visitors to a workplace on different days would see varying activities and events so that the initial provision of information would not be reproducible;

- second, with a series of visitors to a workplace, one would probably soon exhaust the goodwill of management and workers;

- third, managers as they repeated the exercise several times would probably change their answers to questions as they became more familiar with the subject area.

A few instances have been highlighted where the use of simulation differed from giving the participants the opportunity to visit the factory and experience the GRP process first hand. These included:

- the predetermined order of the video (and indeed, which aspects of the process were included);

- the lack of sensory prompts available to participants and;

- the possibility that they interacted with the author in a different manner than would have been offered to the factory manager.

The order in which the process was shown on the video was commented upon by one of the participants as 'disjointed' (See Section 12.3.2 above). However, this followed the route offered to the author by the factory manager, and although not optimum, repeats the events of the risk assessment as would have been conducted on the premises. When making the videotape, the author was aware of the need to show, as far as practicable, an objective account of the GRP process, focusing on stages of work rather than issues pertinent to the risk

assessment. In this way it is thought that the possible prompting or participants via the author's choice of video content has been minimalised.

In any simulation certain aspects will be lost, in this case, the sensory triggers such as noise and smell. In addition to the fact that such deprivation was common to all, the relevant questioning of some of the participants. See questioning about noise or smell highlights the way in which the problem was overcome.

In a qualitative study of this kind, effect of researcher bias as described above can be checked by replication, ie, whether the experiment repeated under the same conditions would lead to the same results (Bryman, 1988). The fact that the experiment has not been repeated is thought to be outweighed by its *replicability,* in that the author has accounted for all steps of the research process, and could feasibly expect another inquirer to competently repeat the study.

12.7 GENERAL ASPECTS

12.7.1 INDIVIDUAL APPROACH TO PROBLEM SOLVING

The study method with its in-built flexibility allowed an individual approach to problem-solving. For example, participants, as part of the basic protocol, were to routinely watch the videotape twice through. This is not to say that they could not watch it for a third time on request and in fact a few did. Having watched the videotape through for the first time, some watched it again immediately with little or no discussion of the factory and its activities with the manager. On the other hand, others asked a whole series of questions between first and second viewings.

Personal aids were not allowed in the exercise. Some commented that in real workplace visits they would have brought their individual checklist to serve as a prompt. It could be argued that these individuals were at a greater disadvantage by virtue of the structure of the method than those who did not routinely use such aids.

12.7.2 VISUAL INFORMATION

In the videotape used, the information supplied is wholly visual. There is no auditory information apart from the factory radio. The absence of olfactory cues such as smells is of note since these may be important in a real HSRA as a means identifying particular substances and with olfactory thresholds for subjectively estimating environmental levels.

12.7.3 OBVIOUS QUESTIONS

The exercise may require people to ask questions which would be obvious in real life: 'Is it a Summer's day?' or 'Is the factory in the UK?' The participant works from visual information to develop a full picture with the help of the manager. This includes the physical size and general lay-out of the factory. In real life one would not need to ask some of these questions since answers would be self-evident.

12.7.4 NON-VERBALISATION OF INFORMATION

One problem with the method was that participants sometimes did not *verbalise* thoughts and impressions during problem solving and therefore these were not captured in the transcripts. This may well have affected (ie, underestimated) the performance of participants who were familiar with the general aspects of GRP processes. It would have assisted analysis to have requested each participant to prepare a brief written report at the end of the session to reiterate their conclusions and recommendations (including some background to their reasoning). With briefings and reminders within the consultation, it is important to repeatedly request that participants verbalise their thoughts and reasoning as much as possible.

12.7.5 PARTICIPANT CONTROL IN THE CONSULTATION

Some participants expressed the wish to have stopped at some point in the videotape and to have examined specific aspects in more detail. In real-life consultations, visitors are likely to influence the course and nature of consultations. Following the pilot study, the assessor was given the video-player remote control and this gave them more autonomy in the exercise.

12.7.6 SHORT TIME AVAILABLE

Only a relatively short period of time was available for each participant to see aspects of the process, its context and to ask any necessary questions. No formal time limit was put on the session and participants were asked to continue with the consultation until they felt that they had enough information to conclude the HSRA and recommend the necessary action. However, in a real consultation much more time would normally be available.

12.7.7 ANXIETY

Some participants were observably more anxious about the consultation exercise, one person expressing the view that they felt the exercise was in part a challenge to their professional credibility. This did not seem to be a common view. Most people cheerfully undertook the consultation sessions without any noticeable anxieties. In general, participants entered into the spirit of role-play including some who expressed initial reservations and/or nervousness.

12.7.8 FLEXIBLE AND ECONOMICAL METHOD

Because of the low costs and flexibility of the approach, there is potential for a relatively large number of participants and topics to be studied than with some other possible methods such as real factory visits. The use of videotape is cost-effective in several ways including the low cost of suitable videotape footage of industrial activities, its ready reproducibility and easy transportation to suitable venues.

A general method for developing case studies is given below (See Section 12.9).

12.8 FURTHER DEVELOPMENT AND APPLICATION OF THE METHOD

It is believed that with some modification, the approach of using videotaped scenarios and role-playing informants could have others applications including:

- realistic problem-solving in risk assessment and other training;
- assessing the competence of students in oral examinations.

12.8.1 RISK ASSESSMENT TRAINING

Further case study scenarios could be developed and the technique used widely in risk assessment and other training. The videotape could be used with individuals or in groupwork. The role-play situation could be used in a range of different contexts. One of the beneficial aspects of the technique is that participants become quite 'involved' in the situation - some became quite irritated with the manager because of his avoidance of some health and safety issues at the factory. Cases could be developed for a wide range of topics as well as risk assessment and with factory managers (For example, a factory process and diagnosing ill-health in role-play with the worker, for trainee occupational health physicians or nurses. Suitable matrices or a generic form could be used to evaluate performance.

With respect to further HSRA scenarios, it would be interesting to use a novel industrial process, which none of the participants is likely to have come across before. Also, when participants ask the manager questions, they should be asked to give reasons for asking a particular question or making a comment. This would assist following their reasoning and approach to the set problem and make analysis of transcripts easier.

12.8.2 ORAL EXAMINATIONS

Students could be asked to carry out a risk assessment (or other) exercise using videotape to present information on the scenario initially. Sound level tapes and olfactory cues such as a smell of solvent or other chemicals could be included in this preliminary provision of information. The examination candidate would then ask the 'manager' questions to elicit further details. Part of the evaluation of the candidate could include, not only technical aspects such as process elicitation and identifying hazards and risks, but also interpersonal and diplomatic skills in dealings with the manager. The candidate could be asked why they asked certain questions and as to their reasoning for particular comments or conclusions. Their performance, possibly using transcripts, could be evaluated on a generic matrix designed for this purpose.

12.9 METHOD FOR DEVELOPING NEW VIDEOTAPE CASE STUDIES

The following procedure is suggested for creating further videotape case-studies:

1. Make contact with a workplace. (This could be for a variety of reasons, for example, to carry out a COSHH or other risk assessment.)

2. Enquire if it would be possible to make a brief videotape of the process.

3. Interview relevant personnel ie, the factory manager, foreman, safety practitioner, nurse, shop floor task operators.

4. Collect all relevant factory, process and health and safety documentation, for example, product hazard data sheets, process lay-out and specifications, (manager's written process diagram/explanation).

5. Edit final videotape into a suitable sequence of reasonably short duration. (5-10 minutes).

6. Depending on the type of risk assessment, show videotape to a small expert panel of health and safety specialists in order to brainstorm relevant questions that could arise.

7. Return to the workplace and re-interview personnel (using an audio tape-recorder and using the portfolio of questions assembled from six above.

8. Organise questions and the responses into a composite role for the 'factory manager'. (This would give a more naturalistic dimension to the factory manager role, since as far as possible, responses to questions would be based on answers generated by the real manager.)

9. Ideally a generic matrix should be used to assess performance in the exercise.

12.10 CONCLUSIONS

1. The videotape knowledge elicitation method is a useful, flexible and economical technique which could be used in risk assessment and other

training and with some modification for evaluation during oral examinations.

2. The method gives insight into not only purely technical skills related to the to risk assessment, but also to into the diplomatic and interpersonal skills of assessors when dealing with managers.

3. In order to assist with the analysis, there should be some modification to the protocol for future work. Participants should be asked to give reasons why they are asking particular questions or making a specific comment.

4. It would be highly desirable to apply the technique using an industrial process with which participants are unlikely to be familiar.

5. A generic risk assessment matrix should be developed from this matrix in this study, which could be used with different industrial processes and tasks. It would be desirable for this to be validated in terms of intra- and inter-analyst variation.

13.

Conclusions and recommendations

13.1 INTRODUCTION

This thesis has examined the process of hazardous substance risk assessment and many of the findings have been discussed in previous Chapters.

The present Chapter draws together conclusions relating to:

- achievement of research aims and objectives;
- models for hazardous substance risk assessment;
- development the videotape knowledge elicitation method;
- risk assessment aids;
- findings of the videotape KE main study;
- recommendations for future work.

13.2 RESEARCH AIMS

13.2.1 CONCLUSION - RESEARCH AIMS

The original overall aims and objectives in this work have been achieved and there have been a range of outcomes from this research.

13.2.1.1 Summary

The basic aim of the research was to explore the nature of the expertise necessary to carry out competent hazardous substance risk assessment in order to help non-specialists carry out this task. Evaluation of performance against

the detailed objectives, cited in Chapter One, is discussed below. In each case conclusions regarding findings are given later in this Chapter.

AIM 1 - to make explicit and investigate the nature of, the expertise of occupational hygienists in HSRA.

- HSRA was investigated by a range of methods - interviews, focused discussions, videotape knowledge elicitation method, development of training and design of an HSRA aid (Chapters Four, Five, Six, Seven, Eight, Ten, Eleven and Twelve);

- the videotape knowledge elicitation method in particular was used in a moulding (GRP) factory;

- two models derived to make explicit the expertise of OH in HSRA (Chapters Seven, Nine and Ten);

- the videotape method was used to reveal the way that the occupational hygienists tackled risk assessment.

AIM 2 - to investigate the approach of other health and safety professionals in HSRA.

- with the videotape method the approach and performance in HSRA of groups health and safety practitioners, occupational physicians, occupational health nurses and trainee health and safety inspectors was investigated (Chapters Four, Six, Ten, Eleven and Twelve).

AIM 3 - to develop an integrated view of contemporary best practice in HSRA and to identify training needs.

- the HSRA Model B was applied to the findings of the videotape study to all expert groups leading to the development of a composite view of contemporary best practice (Chapters Ten, Eleven and Twelve).

OBJECTIVE 1 - the context of hazardous substance risk assessment was reviewed and its scope defined (Chapters One and Two).

OBJECTIVE 2 - hazardous substance risk assessment expertise was identified and its origins and development were discussed (Chapter Two).

OBJECTIVE 3 -current knowledge on the general aspects of 'expertise' were reviewed. This included an examination of the various methods which have been used to study expertise. A methodology was developed for eliciting the expertise of HSRA (Chapter Three).

OBJECTIVE 4 - practical risk assessment (HSRA) aids with complementary training were developed in contrasted organisations to help a non-expert carry out this task (Chapter Eight).

OBJECTIVE 5 - the approach to hazardous substance risk assessment used by occupational hygienists and others was investigated by various methods: exploratory interviews (Chapter Five); risk assessment visits (Chapter Five); focused discussions (Chapter Seven); videotape knowledge elicitation method (Chapter Six (pilot), Chapter Ten, Chapter Eleven, Chapter Twelve).

OBJECTIVE 6 -a practical study was carried out to compare and contrast the approach of representative specialists operating in the field of occupational health and safety. Performance was evaluated both within and between the different groups.

13.3 HSRA MODELS

13.3.1 CONCLUSIONS

1. **Two useful, uncomplicated models of HSRA have been derived, which make explicit various aspects of this activity.**

2. **The models have complementary features and would be helpful in structuring training and in the development of HSRA formats to assist non-experts with the task.**

3. **HSRA Model B was successfully applied to structuring the analysis of consultation transcripts produced in the main videotape KE study.**

13.3.1.1 Summary

This research has led to the development of two models to represent HSRA. Model A is described in Chapter Seven and this was derived principally from a series of focused discussions with an individual expert occupational hygienist. Model A shows the types of information needed for HSRA and represents the activity in three main stages:

- process elicitation;
- detailed exposure assessment;
- determination of the optimum blend of controls with a 'dialogue box'.

Model B, outlined in Chapter Nine, was derived from a variety of sources as outlined in Chapter Four. Model (B) represents HSRA in a series of principal steps:

- process elicitation and task identification;
- task characterisation;
- hazard identification and exposure assessment;
- evaluation/audit of current controls;
- defining exposure workgroups,
- conclusions on risk;
- prioritising tasks for application of controls;
- recommendations.

13.3.1.1.1 Comparing HSRA Models A and B

1. Both models acknowledge the importance of process elicitation/task identification for HSRA to proceed.

2. In Model B the pathway has as a separate stage 'conclusion on risk' whereas Model A implies this occurs in 'detailed exposure assessment'.

3. Model B designates 'identification of workgroups and task specialisation' as an important step in the process. Model A the 'identification of workgroups' is covered within 'detailed exposure assessment'.

4. In Model A the 'dialogue box' illustrates the complexity of the decisions made when selecting and applying control measures.

13.4 VIDEOTAPE KNOWLEDGE ELICITATION METHOD

13.4.1 CONCLUSIONS

1. **The videotape KE method developed was found to be a very useful tool for studying problem-solving approach to, and evaluating relative performance in, the risk assessment exercise.**

2. **Use of videotape created a dynamic scenario in simulated real-time, which was very effective in introducing case-study information in an impressionistic, practical and reproducible form.**

3. **This mode of information provision combined with role-play was a powerful combination which provided insight into both technical and interpersonal skills as used when problem-solving.**

4. **An analytical matrix, based on HSRA Model B and the factory scenario, was derived and successfully applied to an analysis of participant performance using consultation transcripts.**

5. **One drawback of the method is that it is necessary to get experts to verbalise their thoughts otherwise these will not be captured. Although there were briefings and reminders to do this, there is still room for improvement in this aspect. The net result is thought to be some underestimation in the performance of the 'expert'.**

6. **This method could usefully be applied in other subject areas where there is a need to study problem-solving and to assess competency.**

13.4.1.1 Summary

A videotape-based method was developed that was used to elicit from participants from various disciplines their approach to HSRA. The method incorporated:

- a protocol briefing;
- a short sequence of videotape of 6 minutes duration; for example see 'stills' taken from the videotape in (Chapter Ten, pages 207, 208 and 209);
- role-play with the factory manager;
- production of audio-tape transcripts;
- analysis of results;
- evaluation of approaches;
- a scoring system based on model B above.

13.5 RISK ASSESSMENT AIDS

13.5.1 CONCLUSION

Two successful risk assessment aids with training were developed for two very different organisations. Both training and design of the aids gave insight into the HSRA activity particularly as regards the needs of non-experts.

13.5.1.1 Summary

HSRA aids were developed for two organisations (one a multi-national company and the other a small social club), both of which were required to carry out competent HSRA. The aids were supported by written guidance and complementary training as described in Chapter Eight.

For the large company the aid was based on a task hazard exposure assessment and intended for the use of line-managers in carrying out HSRA in their own departments. The strategy assumed that tasks in the production process were identified by line managers using their experience. The aid then provided the following structured route through task hazard exposure assessment:

- definition of task;
- collection of hazard and exposure data (on substances, people and task);
- evaluation and audit of current controls;
- conclusion on health risk;

- recommendations for control,
- action plan (incorporating other task hazard assessments).

Use of the aid was monitored following its implementation at the company. The aid was found to be usable and managers were able to carry out adequate 'primary' risk assessments.

Similarly, at the small organisation an aid was derived to assist with HSRA and this was accompanied by some basic training. It was useful to contrast the differing requirements of the two organisations to achieve the same basic objective.

13.6 RESEARCH FINDINGS - MAIN STUDY (APPLYING VIDEOTAPE KE METHOD)

13.6.1 CONCLUSIONS

1. **Study of transcripts gave insight into approach of hygienists and the other groups when carrying out HSRA.**

2. **As a whole participants in the study identified a wide range of health and safety risks and strategic management issues at the factory.**

3. **The expertise of participant's expertise allowed them to see beyond the requirements of the briefing and there was near universal recognition of fire as risk priority at the factory.**

4. **The different professional groups each showed their own idiosyncrasies when tackling the exercise.**

5. **The combination of the videotape and role-play was very effective in getting participants 'involved' with the factory and its problems.**

6. **Most participants in the study were aware of the limits of their expertise and indicated areas where they thought other professionals should be involved.**

7. **The performance of the hygienists, as a professional group, was highest in the overall exercise as evaluated by the matrix. This group also performed best in most sub-divisions of the matrix. This was the case even with the constraint of not being able to apply some key skills in the exercise, for example, carry out air monitoring at the factory,**
8. **The other professional groups had stronger performances in selected divisions of the matrix and illustrated characteristic preoccupations with certain topics.**
9. **When comparing the hygienist group with the others in the study, the hygienists particularly excelled at process elicitation and the application of specific controls (as far as the scope of the exercise would allow).**

13.6.1.1 Summary

Participants were asked to undertake a hazardous substance risk assessment. Initial information was provided by videotape and by questioning the author (role-playing the factory manager) the participant could obtain further information to complete the task.

The consultation was recorded on audio tape and the content of each consultation transcript was analysed using a structured matrix to evaluate performance. The procedure was carried out with five groups of professional health and safety specialists.

13.7 RESEARCH FINDINGS - EXPLORATORY INTERVIEWS

13.7.1 CONCLUSION

Exploratory interviews with experienced occupational hygienists provided many useful and interesting perspectives on contemporary HSRA philosophy and practice.

13.7.1.1 Summary

Exploratory interviews on HSRA were held with experienced occupational hygienists. The strategic approach of different individual companies as well as the generic aspects of HSRA were covered in these sessions.

13.8 RECOMMENDATIONS

1. The models could be validated and further refined by accompanying occupational hygienists and others as they carry out genuine HSRA surveys.

   This would involve either accompanying the hygienists on an actual visit/or asking them to comment/follow a protocol as they carry out HSRA. The model(s) would be evaluated principally against first, the collection of the necessary data and second, the order in which it is collected.

2. The video KE method protocol could be modified to improve its effectiveness and a validated generic form of the performance matrix should be developed.

   To aid understanding participants could be requested to give reasons for questions and explain comments during the consultations. An alternative approach would be to videotape consultations and replay asking participants to give reasons for and explain comments retrospectively. This would help make comments and problem solving strategies more transparent.

   A generic performance matrix should be produced removing references to GRP and the specific factory process featured in this study.

3. The videotape technique should be applied in other training contexts in both risk assessment and other areas of health and safety. On this basis, further case-studies should be developed.

   A wide range of case studies could be introduced. The scope would depend on the aims/objectives of specific training, which could focus on the whole risk assessment process or selected aspects. In the HSRA context, a little known work process could be used, where it would be unlikely participants would have prior knowledge of activities. Non-continuous industrial processes could be featured such as welding or degreasing.

The inherent complexity of a processes could be varied depending on the skills and knowledge of particular trainees. Similarly the scenario could focus on one specific aspect, for example, personal protective equipment or ventilation provision.

Application of the technique to other contexts in health and safety: The technique could focus on general workplace safety risk assessment in industrial and non-industrial settings. For example, hazards arising from the provision of inadequate machinery guarding could be featured. The consultation with the factory manager could cover both technical and procedural elements of the situation.

The role-play could incorporate a change in the the status of the 'independent person' or visitor, who could become a 'consultant', 'inspector' or 'trade union safety representative'.

The technique would provide a very useful exercise for line managers as part of HSRA training. This would follow an introduction to the basic process (including terminology) and objectives of HSRA.

4. This method could be applied, in a modified form, in oral examinations and other contexts where the evaluation of competency required.

   In oral examinations and other educational assessment the technique could provide a very useful means of evaluating a candidates approach to risk assessment. This could include technical aspects, strategic approach and interpersonal aspects. Candidates could be asked to submit a short written/oral report at the end of the interview and this could be probed by examiners.

   The technique could be applied as a research tool in other areas of occupational health and safety where there is need to study expertise.

5. In the light of the findings of this research and the observed differences between the occupational hygienist and other professional groups, there should be a review of HSRA training of all concerned.

Review of HSRA training of all concerned both HSRA professionals and managers. In each case, the following are key points should be examined:

- the elicitation of processes and tasks systematically and comprehensively;
- consideration of task times;
- identification of task specialisation and exposure workgroups;
- addressing strategic health and safety issues
- interpersonal issues;
- health and safety aspects outside of immediate brief;
- job design and welfare factors.

14. Appendices

14.1 APPENDIX ONE SAMPLE TRANSCRIPT FROM EXPLORATORY INTERVIEWS WITH OCCUPATIONAL HYGIENISTS

Exploratory Interview - Occupational Hygienist C

CH About risk assessment and chemical exposure in workplaces. How do you go about it what things do you look for?

OH(c) You mean just generally? I would find out about the processes that were used to create it and I would work from the rules of experience really. So I would say well what quantities are involved? How many people exposed? Whereabouts? How dusty? How hot? Do people come into intimate contact with it? Do they generate it by their own activities and therefore likely to be close to them or is it something given off in the room? Is it a large workroom? I suppose - volatility - I would look it up if possible - it would give some idea if it is going to evaporate rapidly or not. I suppose more and more I would go on past experience. If it's welding or rubber fume - whatever - I would go on past surveys. What other people found and what I found.

CH What comes to mind? What do you remember from those situations?

OH(c) Surprises where I was surprised. I suppose going back to A... where we did some work together, I was surprised how relatively low exposure to hexane was on the one person we sampled working next to the mixer - given the amount he was splashing about, and how he was handling it. I was amazed that he was not automatically over the hygiene standard. I suppose that makes me think that generally or personally that exposure limits are reasonably practicable limits and I should not really be surprised when I see exposure, relatively gross and out of control - and yet they do not seem to be over the limit (50% over it or whatever). Because the limit is extremely generous, so I should not be surprised - but I am and I like everybody else tend look at results in terms of above or below the limit or some percentage of it - even if the limit is - well not meaningless, it stops gross uncontrolled exposure.

So I assume usually that is the case - not always though - certain limits are so high that you have to work to get above them - the oil mist limit (this is more of a safety limit - to prevent you falling over in the fog!) It is clearly an out of date limit. I suppose rubber fume - I have been surprised many times, there, of how relatively - ten presses at Manchester and about 4 workers, all of them were over the limit - some of them were 2-3 times - and I was surprised. I thought they might be hovering about it or whatever. So it is sometimes difficult to predict. Interestingly, when chemical inspectors in the late 60s started doing measurements, they said that normally they could predict by looking at the process and naming the materials and so on whether exposures were going to be excessive or not. When they actually did measurements, they found usually that their hunches were correct. Sometimes they were caught out - they [exposures] were much higher and sometimes they were much lower which bears out my experience.

CH When were they caught out? {Response is to When was *he* caught out?}

OH(c) The lead soldering survey - that was one of those examples where I was not sure what the results were going to be but we were surprised. But

then when we went back and we thought about it - there is no reason why we should be surprised in that the soldering iron temperature was uncontrolled and I am not sure if we knew the temperature of the furnaces - but they were way above the vaporisation point of the lead. So in retrospect we could see why and I suppose you could have said that would have been predictable if we had asked questions about the temperature of the irons. It is one of those things where one of those IR {infra-red] thermometers would have been very handy. I suppose I find that, however many surveys I go on, I am always learning or re-informing points that I have forgotten.

I will never forget going to H... Rubber Co, coming to a large booth, 3m by about 2m in depth, with just a single spigot at the back - two thirds down there was a huge vortex within it, generated by the suction from the booth, which meant that air was drawn in at the bottom circulated in the main body of the booth and poured out at the top straight into the breathing zone of the person standing there. A really classic example of how you think drawing air out of the booth the air would go into the booth into the hole and out but it did not! So it defies intuition again - until you think about it and you realise what the mechanism is - so I suppose what I am doing all the time is and you are doing as a hygienist, is looking at mechanisms - how the process works and how the process is causing exposure.

If I have got some feel for how that is happening - I feel happier because I have got some connection between the process and the person's exposure and that enables me to make sense of my exposure measurements and also to be able to control it. Until you have got that you are stuck and you are swimming around in a sea of uncertainty. What was your question?

CH How do you assess chemical exposure?

OH(c) In general terms I have not talked about toxicity.

CH How would you carry out a COSHH assessment in general?

OH(c) You look at the toxicity of the materials if that is relatively easily available, the principal products the company makes and principal components that go into the products. Hopefully, therefore the principal materials to which people are exposed - I would rank order it - trying to say - well potential exposure to these substances and materials could be significant - A... was a good example - they were mainly concerned about asbestos really and that was a tiny part of their production. Two people were occasionally exposed to it and I was much more concerned with pesticides which I regarded as potentially very toxic - specially as women were handling them. I do not know why but I felt bad about that - dealing with women who were having children and solvent exposure and again hexane was clearly something I knew to be toxic and volatile, whereas they were using other solvents which were much less volatile and also appear to be much less toxic - so I think in a COSHH assessment I would deal with the main processes first. That can I think catch you out - if some 2 people are using a very toxic material in a tiny little process - occasionally - which could be

very significant for them, but you could miss that, going for the main ones. So you have to beware you can get caught out. Of course if it is particulate of any sort and you have got cleaners these can be significantly exposed - much more so than production workers. The same would apply sometimes to maintenance people - they are a pig - because they are exposed to just about everything on site! Potentially (and yet not usually) - in large quantities - unless it's working with paints and a lot of volatile solvent is being used. There is always a question mark over maintenance actually. It's very difficult to absorb [ie, understand what maintenance is actually taking place].

CH Maintenance personnel need good training.

OH(c) You need to be aware of all the people on site. The best trained and the worst. As a hygienist I tend to look at the process, the chemicals and the exposures. Sometimes of course ingestion can be a significant route of exposure, if not the principle one, and skin absorption. I would like personally to be able to have a good relationship with the occupational health nurse so that we could do biological monitoring together[!] So we get some idea of the dose absorbed. And I am getting more and more interested in doing surface sampling when it comes to particulates - to get some idea of the spread of the contaminant on surfaces in things like washer areas and washrooms - not because you can put any figure (limits) on those numbers, but it just gives you some idea of the degree of spread of the material. We could then bring it to the attention of the management and workers that 'clean' rooms are perhaps not as clean as they thought they were!

CH Are there any situations where you always like to carry out air monitoring?

OH(c) It's more to with experience really - I tend to monitor when I do not know the material and the process fairly well - Isocyanates - this is not an area that I have dealt with that much. The role of the hygienist in many people's eyes is to measure and I do not necessarily think that is the case. I think sometimes it is the icing on the cake say at C... I was looking at silica exposure - we did measurements of exposure and they were significant - but in some ways I was much more excited by the dust lamp measurements. From those I could see where the dust was leaking from, and in terms of convincing of the occupier or the trade union whatever - that something needs to be done and how you can do it - there is nothing to beat a photograph and a dust lamp. A table of figures is very abstract it is a least once removed from what is going on.

So when would I do measurements? I tend to do them every time really - so that I am not caught out - so that if I think conditions are gross I can clearly demonstrate it - if there is a legal limit and they are above it. Also because with some airborne contaminants you cannot see, taste or smell - normally you have to rely on instrumentation.

CH Except small companies doing COSHH assessments are not in a position to measure every time?

OH(c) They are not in a position to do that. You asking me what I would do? What occupational hygiene needs is a memory - a way of relatively easily accessing [information on] past exposures to similar processes. I mean that sort of exists in a patchy way - like with welding - there was a paper in the Annals [Annals of Occupational Hygiene Journal] recently from a Danish group (Dutch?). Then you could say that if you are using - manual metal arc and stainless steel - you are likely to be over the limit for chrome 6, but not over for nickel, for example. Now the company doing that work does not have to do measurements really - they just need a database to get access to. As time goes by it will be possible to build it up.

I have been asked to make an expert witness statement on the likely silica exposure of somebody fettling castings which are covered in sand and have not been shotblasted. When I make enquiries I find that in fact it very much depends on the size of the castings, the duration of the work and if you have to get inside the castings to fettle them - whether the person is likely to be above or below the limit.

A small company if they could tap into a database - they could say small castings intermittent usage - the database would come back and say - probably not above 0.1 silica. It is not simple - you would have to go through the thought processes the same as I have done. You would want quite a bit of information about the process, product, the work method, the duration of the work during the day and the pattern over the week. Putting all that together you probably say you know - 90% probably 'not above' or 100% certain you are not 'above the limit' - or a certain number. You do not have to use the limit - you could a fraction of the limit if you are a cautious employer. In a sense (I do not know what I feel about that), that is a good way of saving you a good deal of effort, time and money.

OH(c) Small companies cannot afford all this monitoring and it is pointless doing it endlessly for endless small companies. I think really trade associations should get their act together and supply that sort of service. I am not sure that they will - but that is what I think they should do - to be encouraged to do. I mean, having said that, I do not think control of toxic risk is just about limits and measurements, because I think that there is always a relationship between processes and levels of exposure. You could do as I describe and look at the process and either say yes you are above or you are below the limit - or look at the process and say while it is offensive or irritant material - there is no limit for it - let us just control it. And then with a dust lamp to make some judgement to see whether control is adequate. If anything, you can say - are people still being offended by it? If no - then you are OK.

I personally think that is a perfectly valid way of dealing with what is a very uncertain topic - you know if we had 500 limits in this country and 50,000 chemicals in regular use. I think this a major flaw in the direction in which HSE has gone - to rely upon magic numbers of one kind or another. I mean large companies have difficulties in generating internal limits for their own use and small companies have not got a hope. So I think we are back into the good old days of S63 [Factories Act 1961) and

other similar Sections in other Regulations, which say 'if it is dusty you shall control it'. They do not say to what level – that is a problem - especially in a situation where the dust is invisible respirable dust. I think sometimes that the HMFI has been caught out – like with silica dust in foundries. I think just looking at it you cannot tell whether you are above or below the limit. With a dust lamp you can get more information - but you need to know the foundry industry quite well. Asbestos – that is another one where the degree of dust control required to get to 0.5 fibres/ml is actually so severe you can not make a judgement based on relatively crude 'just control the dust' type of commands. How you would build this into an expert system I am not sure, because limits is nice and easy, a general exhortation to control dust or fumes whatever is.

CH We need to use some sort of limits – the idea is to get a manageable system for somebody who has not got the expertise (at the basic level) to do an elementary COSHH assessment. I have not interviewed non-experts yet to see what problems they have had trying to do COSHH, although I have probably got some ideas as to where they are having problems. [Interview was prior to HSRA training for managers]

OH(c) I think the problems that are probably occurring - that one is a toxic one or this one has a limit – that sort of mesmerises them – so the fact that it has a limit and that it makes up 1% of the mix and it is not very volatile means that you can basically ignore it. But I think the trouble is – people will home in on those substances that are listed in EH40 [HSE's published list of occupational exposure limits] or Sax [Standard textbook, Sax (1992)] lists as toxic and not relate it to the percentage in the material being handled or the way it's handled. I think some people would do that and others would be more logical about it - we do not really handle it in a way in that it would be generating or released into the air. A factory inspector recently got excited about isocyanates in an adhesive - produces a tiny amount of MDI [Methylene disocyante], he was going to do the company under Section 6 [Health and Safety at Work etc. Act 1974] for not mentioning the isocyanates on the label. That's crazy there is very little risk. We [the Specialist Inspector Group] would not back him on this. In some ways – if it's moving it's prosecuted! In some ways I object to that approach – it's too ready with the prosecution I think.

CH Manufacturers often call materials 'nuisance particulates' by default – where there is not much information?

OH(c) It's a fall back if you have no information - you could say 'unknown' - to call it a 'nuisance dust' is a positive decision. You are saying that as far as we can tell from the toxicology of the material – what we know of it - it does not appear to have any active biological effect. But to be absolutely sure you need to have some data at least an LD_{50} [Basic acute toxicity test] otherwise you are guessing. You should say 'we do not know' – otherwise we would be applying the nuisance dust limit. I think that manufacturers will find that very difficult to do. They will not want to put 'unknown' and yet it is unknown. You could say

unknown and then apply nuisance dust as it is a particulate. There will be a lot about of that I think.

(CH There are plenty of areas where there is very little [HSRA] expertise, for example, the NHS?

OH(c) Yes, well I can see that an expert system can help them there.

CH 'Expertise' is quite an intangible thing really?

OH(c) I feel torn by this – I think in some ways it should be possible to distil it - if we had better models – in a sense that if you said - people are using these materials in these quantities under these circumstances, so much surface area is exposed – it seems to me it should be possible to predict the rate of emission of the vapour, then you need to have some idea of the dilution rate and the specific area of that workplace to give you some ball park of what the likely exposure of the people working there would be. There has been some work done on that – some Dutch workers published a paper in the Annals recently about the prediction of exposure to paint solvents under different circumstances. Interestingly, some of the results were counter-intuitive (like it is highly mathematical and I do not understand it all) but I did try to grapple with it a bit – they were saying that if you try to increase the ventilation rate under some circumstances you make conditions worse because you cause more evaporation of vapour. Because you have increased the ventilation rate it actually goes completely against what you think. You open the window – you think exposure is bound to go down. The model does not predict the actual numbers but what it is saying is that this sort of thing will happen in these circumstances and I think that those sort of models give you a general feel for how things might happen.

CH Not sure how quantitative or semi-quantitative things will be?

OH(c) Yes mimic problems – you might find hygienists to differ in approach. I think it is such a giant subject, potentially. So that I feel quite comfortable in the biological aspects of it and the engineering side of it I do not find that difficult. Where I do feel I need to ask advice – is in chemistry. That is the point about hygiene - it is a strange subject, it straddles a number of disciplines, and the thing that the hygienist needs to learn today is – 'I have integrated a lot of different subjects and I do not need to know them all in depth'. But if you are feeling insecure there is a tendency to go back to what you know – so if you are an engineer you go back to engineering, or a chemist and so on. That ultimately damages the subject [ie, hygiene] because I do not think that occupational hygiene is biology or chemistry or engineering – it is a synthesis of all those together – that's the power of occupational hygiene.

It is continually being eroded by not only a lack of confidence within the profession, but also by claims of other professions and other perceptions as well. The Factory Inspectorate regard occupational hygiene as just measurements and it must be said that [UK] occupational hygiene developed within the Factory Inspectorate and

now with specialist inspectors – their whole history is of measurement – so they regard themselves as 'measurers' - self-perpetuating! I do not find that so much of a problem yet but it may be ultimately.

CH The Factory Inspectorate employs very few ventilation engineers or others concerned with control?

OH(c) There are very few now. Hamion who wrote the book entitled: "*Process Ventilation*" lovely quote – "People get seduced by the beauty of building complicated ductwork systems, air volumes and velocities that they forget about the hood end of the system" which is absolutely the point that you need to get right. You could also go one further to say – do we need all this ventilation in the first place? How about changing the process or the work method or substance?

I do not think it is simply a matter of where you are coming from as a hygienist or an engineer or a chemist there are also cultural factors – commercial factors which push the company in that direction and they - if you are dealing with a process which has not changed for a long time and you come along to an industry and you say – we think you ought to think about re-designing your process – they would put up their hands in horror. Or they are pinned down by other things - I went to a company recently who do electrical soldering and I said why do you not move to a non-multi-core non-colophony cored solder. They said we cannot because the Ministry of Defence specify in their literature you shall use multi-core solder. MoD are very conservative, they do not like to change. You could say – eliminate the colophony problem by changing the solder – in that case it is difficult.

It takes a few to break ranks within an industry and then others start to think in those terms - or external forces. I think there are going to be changes in the paint industry with things like degreasing solvents and movement towards water-based alternatives. Because of pollution control - what do we do with the waste - you can not emit that amount of 'Trike' [Trichloroethylene] and you will have to control it. This is going to force change. I am disappointed that industry cannot think in those terms all the time.

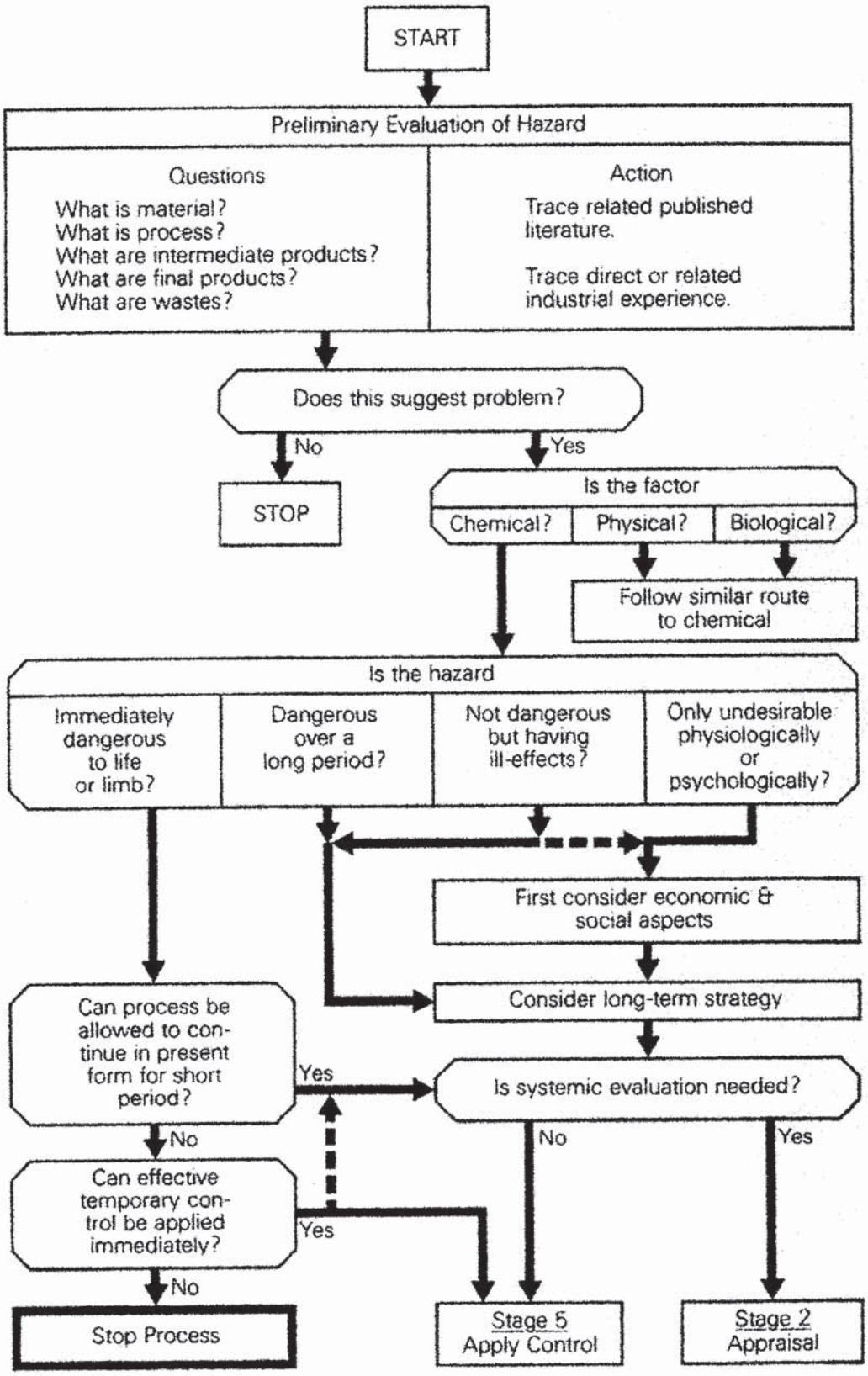
CH Glycol ethers in printing inks? [Recent case in point]

OH(c) They are still in other areas though - my general impression is that there is a lot of movement, which is an exciting time for the hygienists in that if products are changing and processes are changing and you are in there trying to get your 6 pennies worth – you could potentially improve things quite a lot. There are some running sores on the control side that I do not think that anyone is addressing properly – use of LVHV [Low volume high velocity ventilation] systems on hand-held tools. It is applied and they find it is too heavy and too awkward. It cannot be used and it is thrown away and left to rust. I feel it is a solution that can be made to work but it needs much more effort. Design and ergonomic effort by the manufacturers of the tools. So it is one of those solutions that does work, but does not, because the effort has not been put into it. It's always one of those things that HSE could grasp – not to do the design but to do an ergonomic hygiene research

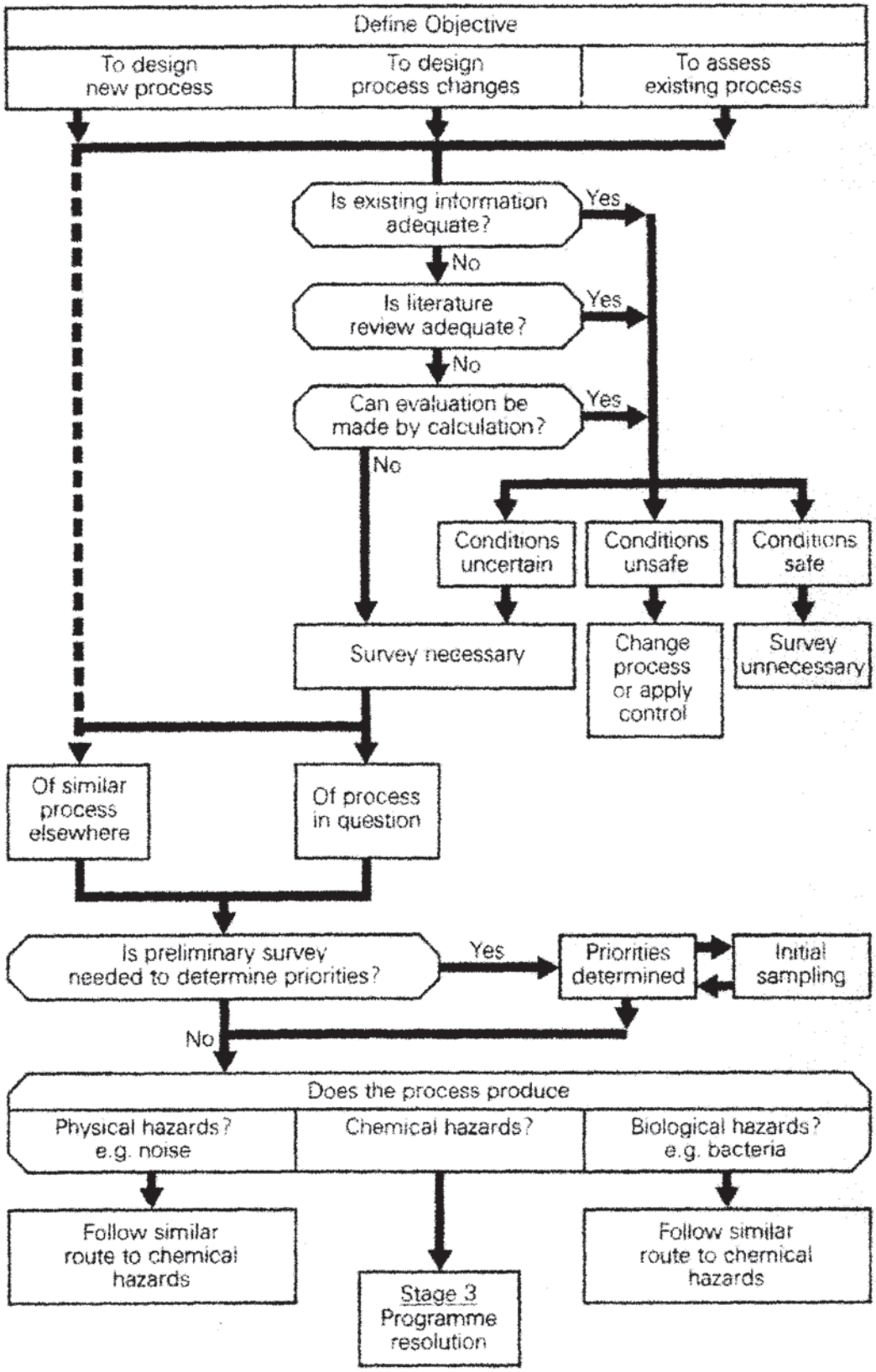
project and give people a sort of a guide as to how to produce well designed and ergonomically acceptable LVHV. Some of the things you could do.

End of interview.

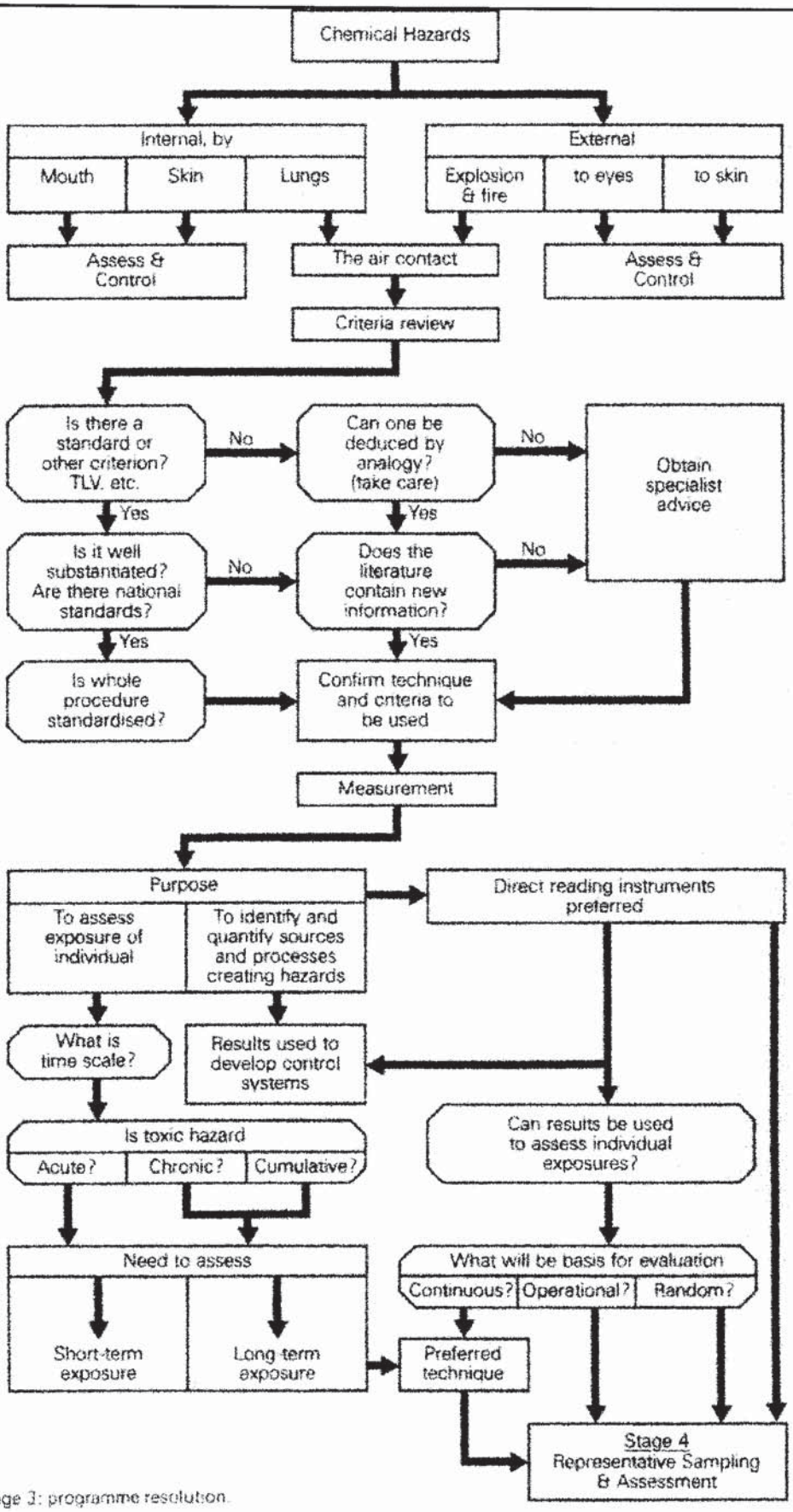
14.2 APPENDIX TWO SHERWOOD AND ALESBURY MODEL FOR OCCUPATIONAL HYGIENE



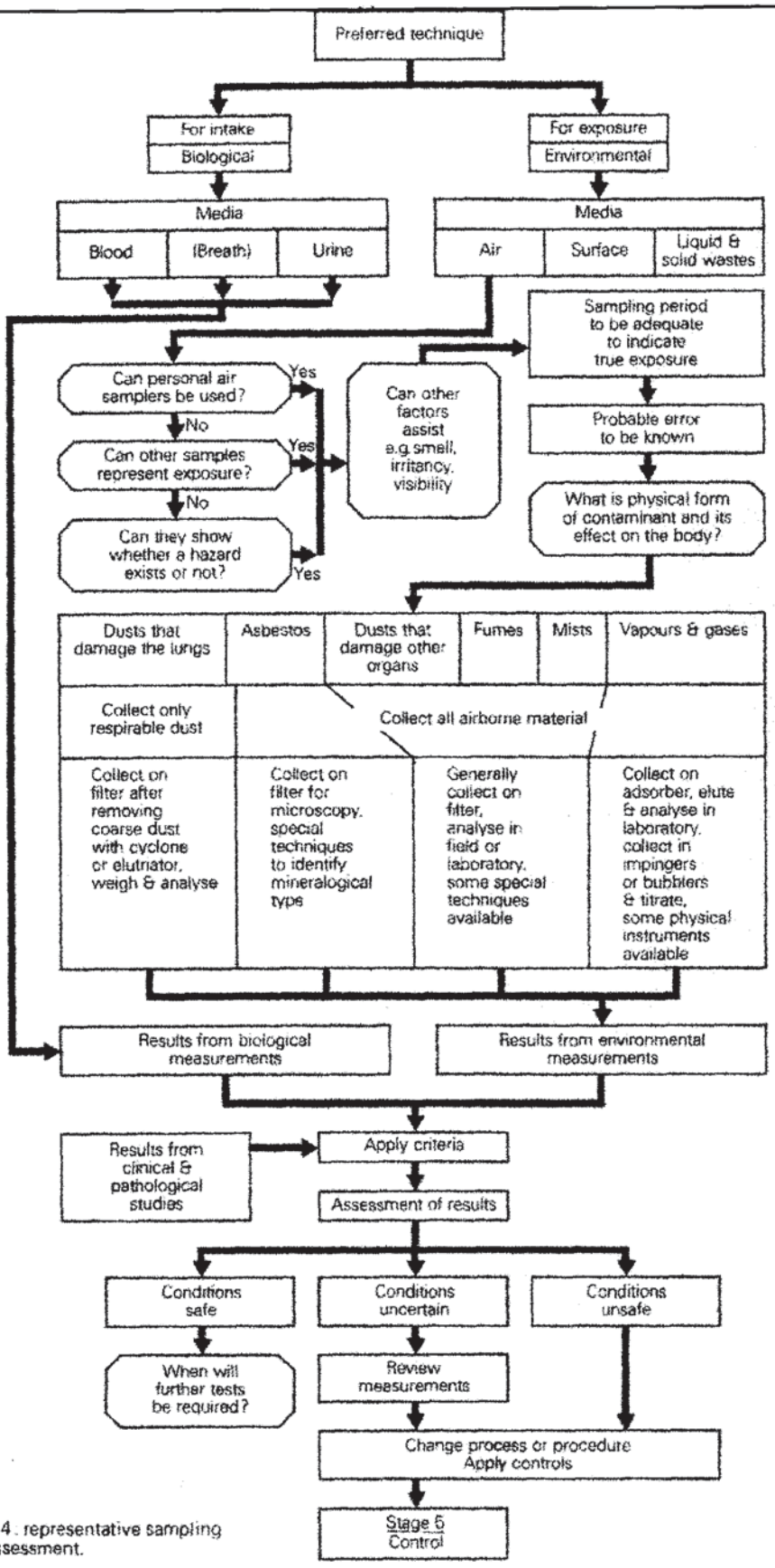
Stage 1 : preparation.



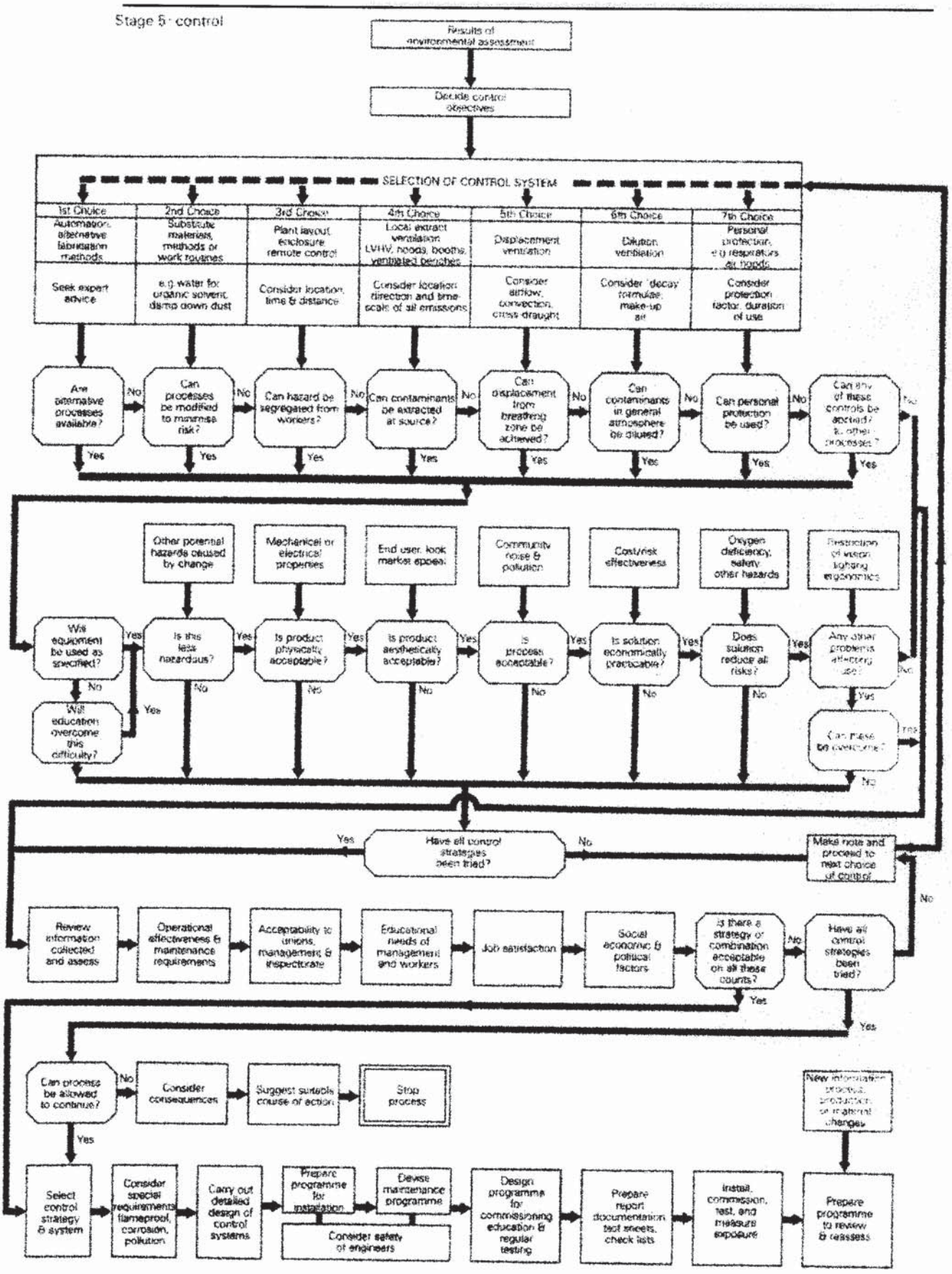
Stage 2: appraisal



Stage 3: programme resolution



Stage 4 . representative sampling and assessment.


Stage 5 - control
Results of environmental assessment
Decide control objectives
SELECTION OF CONTROL SYSTEM
1st Choice
Automation, alternative fabrication methods
Seek expert advice
2nd Choice
Substitute materials, methods or work routines
e.g. water for organic solvent, damp down dust
3rd Choice
Plant layout, enclosure, remote control
Consider location, time & distance
4th Choice
Local extract ventilation: LV/HV, hoods, booths, ventilated benches
Consider location, direction and time-scale of all emissions
5th Choice
Displacement ventilation
Consider airflow, convection, cross draught
6th Choice
Dilution ventilation
Consider 'decay' formulae, make-up air
7th Choice
Personal protection, e.g. respirators, air hoods
Consider protection factor, duration of use
Are alternative processes available?
Can processes be modified to minimise risk?
Can hazard be segregated from workers?
Can contaminants be extracted at source?
Can displacement from breathing zone be achieved?
Can contaminants in general atmosphere be diluted?
Can personal protection be used?
Can any of these controls be applied to other processes?
No
Yes
Other potential hazards caused by change
Mechanical or electrical properties
End user, look, market appeal
Community noise & pollution
Cost/risk effectiveness
Oxygen deficiency, safety, other hazards
Restriction of vision, lighting, ergonomics
Will equipment be used as specified?
Will education overcome this difficulty?
Is this less hazardous?
Is product physically acceptable?
Is product aesthetically acceptable?
Is process acceptable?
Is solution economically practicable?
Does solution reduce all risks?
Any other problems affecting use?
Can these be overcome?
Have all control strategies been tried?
Make note and proceed to next choice of control
Review information collected and assess
Operational effectiveness & maintenance requirements
Acceptability to unions, management & inspectorate
Educational needs of management and workers
Job satisfaction
Social economic & political factors
Is there a strategy or combination acceptable on all these counts?
Have all control strategies been tried?
Can process be allowed to continue?
Consider consequences
Suggest suitable course of action
Stop process
New information, process, production or material changes
Select control strategy & system
Consider special requirements, flameproof, corrosion, pollution
Carry out detailed design of control systems
Prepare programme for installation
Consider safety of engineers
Devise maintenance programme
Design programme for commissioning, education & regular testing
Prepare report, documentation, test sheets, check lists
Install, commission, test, and measure exposure
Prepare programme to review & reassess

14.3 APPENDIX THREE RISK ASSESSMENT AID FOR MANAGERS (ORGANISATION X)

HAZARDOUS SUBSTANCE RISK ASSESSMENT PROFORMA

SITE:
ASSESSMENT NO:
Department:
Area:
Process No:
Task:

Substances	Ref. No.	Hazard*										Physical form*				Contact with body*				How often exposed?					Period exposed?				Exposure limit?				
		very toxic	toxic	corrosive	harmful	irritant	highly flammable	flammable	carcinogenic	sensitiser		fume/gas/vapour	liquid	dust/powder	solid	inhalation	ingestion	skin	eye	daily	once/twice a week	once/twice a month	less than once a month	no exposure	most of the day	up to half a day	less than one hour a day	less than 5 minutes a day	HSE MEL	HSE OES	HSE General dust	Co. Standard	Group HAZARD ID No.

Please describe the process/task under normal working conditions and identify equipment used: (attach sheet if necessary)

Tick box if additional sheet attached ☐

What process or task failures could lead to exposure to the above substances? (attach sheet if necessary)

Tick box if additional sheet attached ☐

Who is exposed?

	Normal Working	System failure Type:	System failure Type:
Task Operator(s)	☒	☐	☐
Labourers	☐	☐	☐
Cleaners	☐	☐	☐
Supervision	☐	☐	☐
Maintenance	☐	☐	☐
Contractors	☐	☐	☐
Others	☐	☐	☐

*Tick more than one box if necessary ** Please leave BLANK at present

Current Practice

	Control Measures	Adequate?	Adequate use?	Adequate review or maintenance?	Adequate records kept?
	yes no	yes no	yes no	yes no	yes no
Local Exhaust Ventilation (LEV)					
General ventilation (fans and vents etc)					
<u>Personal protection equipment (PPE):</u>					
Respiratory protective equipment (RPE)	Type:.....				
Eye/face protection	Type:.....				
Gloves	Type:.....				
Protective clothing	Type:.....				
Specified site spillage procedure					
Specified site disposal procedure					
Permit to work for maintenance					
Eating/drinking restriction					
Smoking restriction					
<u>Information Instruction and Training for employees</u>					
Normal working					
Emergency procedures/system failures					
Use of PPE					
Housekeeping					
Has air monitoring been carried out?	<u>Comments:-</u>				
Is specified health surveillance normally associated with this task?					

Indicate conclusions about risks to health:	During normal working	System failure(s) 1.....	System failure(s) 2.....
Risk to health unlikely Risk significant - all adequate precautions in force Risk significant - further precautions need to be applied (see over) Uncertain about risks to health - further information required Uncertain about precautions necessary - further information required			

Recommendations - *Further* action required

Tick box if NO actions required: ☐

(Note:where external help needed see back of form)

Item No.	Control measure required?	yes	no	action completed		Use of measures?	yes	no	action completed	Review or maintenance of measures?	yes	no	action completed	Records?	yes	no	action completed
1	Eliminate substance(s)	☐	☐	☐											☐	☐	☐
2	Use less harmful substance(s)	☐	☐	☐											☐	☐	☐
3	Process re-design	☐	☐	☐											☐	☐	☐
4	Local Exhaust Ventilation	☐	☐	☐			☐	☐	☐		☐	☐	☐		☐	☐	☐
5	General ventilation (fans and vents etc.)	☐	☐	☐			☐	☐	☐		☐	☐	☐		☐	☐	☐
	Personal protection equipment (PPE):			☐													
6	Respiratory protective equipment (RPE)	☐	☐	☐	Type:.....		☐	☐	☐		☐	☐	☐		☐	☐	☐
7	Eye/face protection	☐	☐	☐	Type:.....		☐	☐	☐		☐	☐	☐		☐	☐	☐
8	Gloves	☐	☐	☐	Type:.....		☐	☐	☐		☐	☐	☐		☐	☐	☐
9	Protective clothing	☐	☐	☐	Type:.....		☐	☐	☐		☐	☐	☐		☐	☐	☐
10	Specify site spillage procedure	☐	☐	☐			☐	☐	☐		☐	☐	☐		☐	☐	☐
11	Specify site disposal procedure	☐	☐	☐			☐	☐	☐		☐	☐	☐		☐	☐	☐
12	Require permit to work for maintenance	☐	☐	☐			☐	☐	☐		☐	☐	☐		☐	☐	☐
13	Housekeeping	☐	☐	☐	Please specify:.....												
14	Eating/ drinking restriction	☐	☐	☐			☐	☐	☐								
15	Smoking restriction	☐	☐	☐			☐	☐	☐								
	Information Instruction and Training for employees																
16	Normal working	☐	☐	☐			☐	☐	☐		☐	☐	☐		☐	☐	☐
17	Emergency procedures/system failures	☐	☐	☐			☐	☐	☐		☐	☐	☐		☐	☐	☐
18	Use of PPE	☐	☐	☐			☐	☐	☐		☐	☐	☐		☐	☐	☐
19	Information leaflets/warning notices	☐	☐	☐			☐	☐	☐		☐	☐	☐		☐	☐	☐
20	Written task description	☐	☐	☐			☐	☐	☐		☐	☐	☐		☐	☐	☐
21	On-the-job instruction and training	☐	☐	☐			☐	☐	☐		☐	☐	☐		☐	☐	☐
22	Other	☐	☐	☐			☐	☐	☐		☐	☐	☐		☐	☐	☐

Assess. No.

Action plan and general comments:

Item No.	Action Required	Person	Target Completion date

Assessor's name:.....

Signature:..... Date.....

Reviewer:..... Date.....

Date above action completed: .....

Date of assessment review: .....

To be completed by Health & Safety & Medical depts.

Air monitoring required? (Reg.10) yes ☐ no ☐

Comments

signed..... date.....

Health surveillance required? (Reg.11) yes ☐ no ☐

Comments

signed..... date.....

(000145)

page 4

Organisation Y COSHH Assessment Form	
Task	
Description of task	
Hazardous substances used	
Nature of the hazard	
Precautions required	Precautions in actual use
Conclusion on risk 1. risk adequately controlled - all control measures in force ☐ 2. risk not adequately controlled - further control measures needed ☐ 3. cannot decide on risk - more information needed ☐	
Recommendations	
Assessor Date	Review date

14.4 APPENDIX FOUR VIDEOTAPE CASE-STUDY: HAZARD DATA SHEET

BEETLE RESIN R888E

Chemical or Technical Name

Polyester resin in styrene (pre accelerated).

Composition

Unsaturated polyester resin in solution in styrene; contains accelerators and thixotropic additives.

Properties

Description	Purple, opalescent thixotropic liquid smelling of styrene
Flash Point	31°C (Closed Cup)
Specific Gravity	Approximately 1.10 at 25°C
Viscosity	Approximately 2.5 poise (0.25 Pa.s) at 25°C at a shear rate of 165.15 sec^{-1}
Solubility	Insoluble in water. Soluble in xylol, acetone

Use

This resin is used in the fabrication of fibre-reinforced mouldings, laminates, extrusions and sheeting and in unreinforced castings. The product does not contain fire retardant additives and should not be used for any application where fire retardancy is required.

If the resin is used for any other purpose the advice of BIP Chemicals Limited should be sought regarding additional hazards that may arise.

Finished articles made from the resin are not suitable for use in contact with food or potable water.

First Aid

Skin Exposure - Remove contaminated clothes. In the event of contact with the skin, remove excess resin with a clean cloth. Clean the skin with a suitable proprietary cleansing cream and wash with large volumes of water (or soap and water). If irritation persists, or any sign of tissue damage is apparent, obtain medical advice immediately.

Eye Exposure - In the event of contact with the eyes, irrigate copiously with water for at least ten minutes; obtain medical advice if irritation persists or there is any tissue damage.

Ingestion - In the event of accidental ingestion, rinse mouth with water, give up to half a pint of milk or water to drink; obtain medical advice immediately.

Inhalation - In the event of excessive inhalation, remove the individual to fresh air and keep at rest; obtain medical advice immediately.

General Comment - As in all cases of potential poisoning, supportive therapy is of the utmost importance.

Health Hazards

Styrene is classified as irritant. Vapours can irritate the eyes, throat and nasal passages. Skin contact can cause defatting leading in some cases to dermatitis. Accidental ingestion can cause gastrointestinal irritation. High concentrations of solvent vapour can cause dizziness, nausea and headache.

Dust can be created by the machining of finished moulded products; the dust concentration in the atmosphere should be kept as low as is reasonably practicable and under no circumstances should it exceed the Occupational Exposure Limits for nuisance dust (see below).

When local extraction equipment is provided for dust control it is important to remember that the dust (in sufficient concentration) constitutes a fire and explosion hazard and that the dust collection plant must be provided with explosion relief.

Occupational Exposure Limits

	Long-term Exposure Limit (8 hour TWA value)	Short-term Exposure Limit (10 minute TWA value)
Styrene (control limits)	100 ppm	250 ppm
Total inhalable dust	10 mg/m^3	-
Respirable dust	5 mg/m^3	-

Personal Protection/Handling Precautions

Wear protective clothing including gloves, eye shields, footwear and overalls.

Ensure adequate ventilation such that the concentration of solvent vapours in the working atmosphere is kept as low as is reasonably practicable and under no circumstances should it exceed the occupational exposure limit.

Good industrial and personal hygiene should be observed. Food or beverages must not be prepared or consumed in areas where this resin is processed or handled.

Fire and Explosion Hazards

The resin will burn giving off toxic fumes. Styrene is flammable and can present fire and explosion risks - explosion limits 1.1-6.1% v/v in air.

Static electricity may be generated when the resin is conveyed through pipelines to storage tanks, vessels or bulk carriers. Because of the attendant fire risk, splash filling should be avoided, and pipelines and vessels must be earthed and bonded. Road tankers should be earthed when charging or discharging. A powder or carbon dioxide type fire extinguisher should be provided in the vicinity when charging or discharging vessels. A fire alarm point, clearly marked, should also be provided.

Where a flammable atmosphere could be formed, lighting, heating and other electrical equipment must be in accordance with the standard laid down in BS CP 1003 or IP Model Code of Practice.

The resin should be handled and used in well-ventilated, flame proof areas, preferably in enclosed systems. Smoking must be prohibited. (See Highly Flammable Liquids and Liquified Petroleum Gases Regulations 1972; Statutory Instrument 917, 1972).

Dust from machining of finished products constitutes an explosion hazard (see Health Hazards).

Fire Fighting Recommendations

Suitable fire extinguishers: Dry powder, carbon dioxide or foam
Wear self-contained breathing apparatus.

Water is unsuitable, but may be used to cool tanks, containers and drums in the proximity of fires, to prevent overheating and consequent explosion or spread of flames.

Storage

Storage is subject to the Highly Flammable Liquids and Liquified Petroleum Gases Regulations 1972; Statutory Instrument 917, 1972.

Store below 20°C in closed opaque containers in a well-ventilated flame proof area. This resin contains an inhibitor to prevent premature polymerisation. The inhibitor may be slowly depleted during long storage, particularly at temperatures appreciably above 20°C. Inhibitor depletion may allow spontaneous polymerisation to begin. In a bulk quantity of resin solution this polymerisation may accelerate rapidly because of the heat generated and there is a risk of an explosion in the container, and of fire from the highly flammable vapours.

Storage areas must be selected to avoid accidental exposure of bulk resin to fluorescent lighting, sunlight or heat. Exposure to UV radiation, eg from fluorescent light fittings, may initiate a slow polymerisation that can continue in a re-sealed container.

Contamination with certain materials, eg alkalis, reduces inhibitor concentration, and increases the risk of spontaneous polymerisation. Oxidising agents (eg inorganic and organic peroxides and related compounds), strong acids such as sulphuric acid, ferrous salts present in rust, and some metal halides can also promote polymerisation. Contamination of this resin with these substances must therefore be avoided and they should be excluded from the storage area.

Spillage/Waste Disposal

Remove all sources of ignition. Absorb any spillage on dry sand or a similar inert material and place in a container for disposal, either by controlled incineration or by approved landfill. This resin is regarded as notifiable for the purposes of The Control of Pollution Act 1974 and The Control of Pollution (Special Waste) Regulations 1980 SI 1709 and advice should be obtained from the Local Authority regarding disposal.

Should any resin solution enter the public drains or waterways, the local Water Authority and the Police must be informed.

Empty Containers

Emptied containers retain vapours of styrene and are therefore hazardous in respect of fire, explosion and noxious vapour risks. They should be stored away from all sources of heat and ignition and should only be disposed of through reputable reconditioners.

Hazardous Goods Classification

CPL Regulations	Supply - Flammable, irritant Conveyance - Flammable liquid
UN Number	1866
UN Hazard Class	3
UN Packing Group	III
ADR/RID	
Class and Item Number	3.31°(c)
Hazard Identification Number	30
IMO/IMDG	
Page Number	3153
Class	3.3
UK Road Transport	
Emergency Action Code	3Y
Tremcard Number	BIP 2

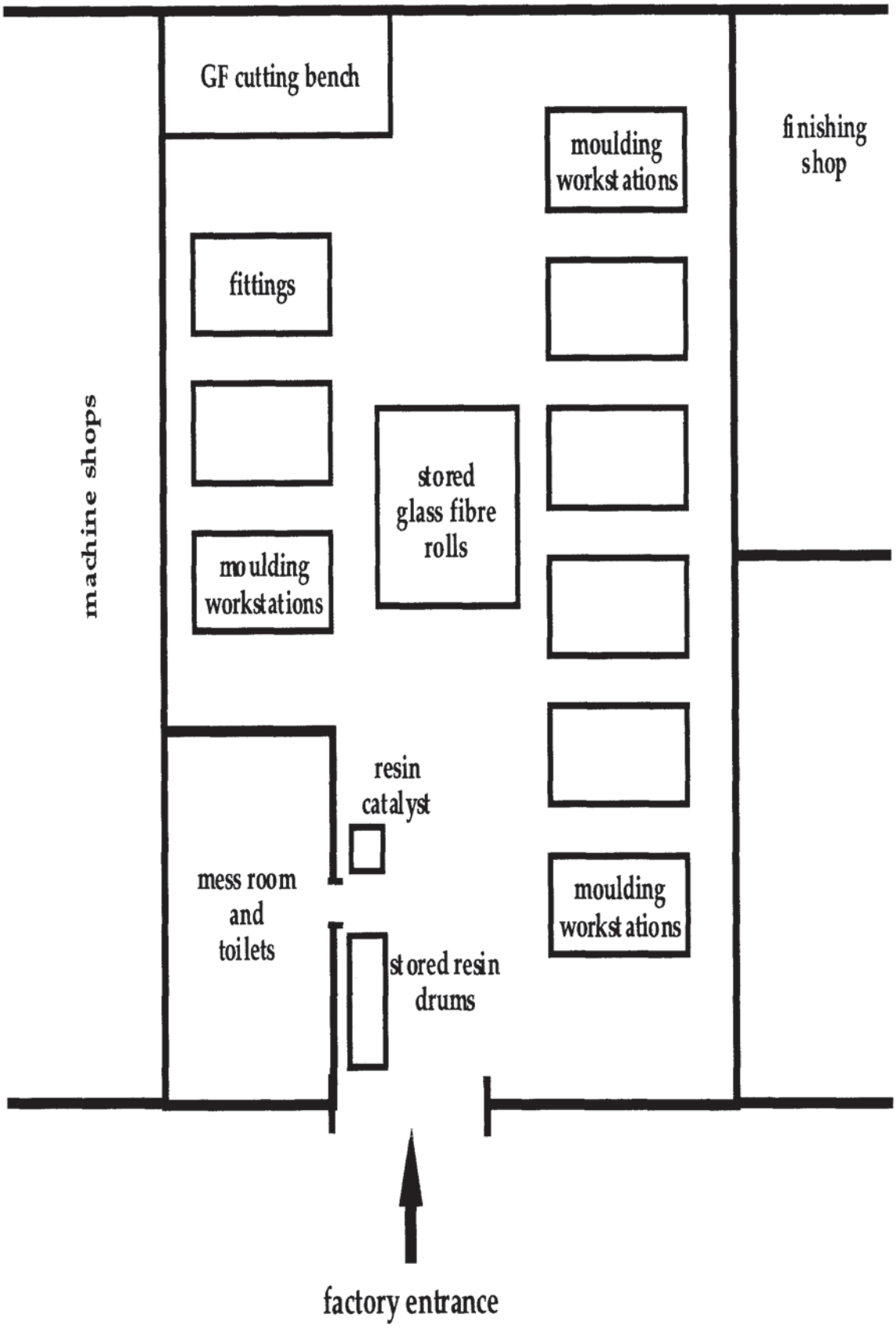
Supplementary Information

The resin does not contain any deliberate addition of lead or lead compounds.

Whilst every care has been taken in the preparation of this Information Sheet, the same has been produced from information and data currently available to BIP Chemicals Limited at the date hereof; however, BIP cannot be responsible for any errors or omissions. If in any doubt, please consult BIP Chemicals Limited.

January 1989

14.5 APPENDIX FIVE VIDEOTAPE CASE-STUDY: FACTORY LAY-OUT


GF cutting bench
moulding workstations
finishing shop
fittings
machine shops
stored glass fibre rolls
moulding workstations
resin catalyst
mess room and toilets
moulding workstations
stored resin drums
factory entrance

14.6 APPENDIX SIX VIDEOTAPE CASE-STUDY: DEVELOPMENT OF WRITTEN BRIEFINGS

BRIEFING ONE (Pilot Study)

Hazardous Substance Risk Assessment - Knowledge Elicitation

Briefing Notes

Thank you for agreeing to participate in this investigation.

The long-term aim of this research is to develop a useful computer aid to hazardous substance risk identification and assessment, in the form of an *expert system.* Many expert systems in the past have extracted the knowledge of experts and have simulated the way that these individuals have solved problems in their particular knowledge domain. This knowledge has then been suitably structured in the form of an expert system computer system. The knowledge needs of potential users have rarely been looked at in the development of this type of system.

One aim of this research is to study how various groups of approach this type of problem solving, so that this can be similarly incorporated into the above type of system.

A tape recorder will be used to record the interview.

The interviews are confidential.

The session is broadly divided into two parts:

a) Hazardous substance identification and general observations

Watch the video (6 minutes) whilst at the same time 'thinking aloud'. Describe observations and questions that arise.

The primary purpose is hazardous substance risk assessment, but if you wish make wider comments concerning health and safety.

b) Preliminary risk assessment

Carry out a preliminary risk assessment on the basis of a 'walk through' via the video.

Question the investigator (as a substitute for the workshop manager).

Try and verbalise what is going through your mind as we proceed through the problem.

VIDEOTAPE CASE-STUDY BRIEFING TWO (Intermediate form)

Assessing health risks from hazardous substances

Briefing

You will be shown some brief industrial case studies on videotape. The primary purpose of the exercise is ***to assess risks to health from exposure to hazardous substances*** in the scenarios presented. Describe the observations and questions which arise.

After viewing each case study, when carrying out your review I would also like you to draw attention to other hazards you have observed together with other health and safety issues and the effectiveness of health and safety management at the particular premises.

The interview session will be conducted as follows:

i) Introduction and briefing

ii) Viewing the videotape (Case 1)

Asking questions to establish all you need to know

iii) Five minutes consolidation of observations, conclusions and recommendations

iv) Interviewer's confirmatory questions

v) Viewing the videotape (Case 2)

Asking questions to establish all you need to know

vi) Five minutes consolidation of observations, conclusions and recommendations

vii) Interviewer's confirmatory questions

viii) Debriefing

Even with something obvious in the videotape scenario please ask for empirical information for example using questions such as *Can you tell me.....?* or *Can you confirm that.....?* Try to think of the questions you would like to ask the manager if your were at the premises. Please ask confirmatory questions even where you are reasonably sure about the answer.

After viewing the videotape and asking any appropriate questions there will be five minutes for writing down basic conclusions/recommendations primarily relating to hazardous substance risk assessment.

I will ask a series of questions to establish the basis on which you make your recommendations and conclusions.

The whole interview will be confidential and the purpose is not testing but to research into the way people with your training and background experience are likely to approach this type of problem solving exercise.

Thank you very much for your time and cooperation with this exercise.

VIDEOTAPE CASE-STUDY BRIEFING THREE (Main study)

Assessing health risks

Briefing to participants

The purpose of the experiment is to find out how someone with your training and experience is likely to approach the assessment of health risks in a workplace. To make the best use of the time available I am taping our discussion.

You are an independent **advisor** who has been requested to:

(i) **Assess health risks in a factory**

(ii) **Recommend necessary action**

(In this context you are not acting as an inspector nor have you any formal inspection powers)

Visual information about the factory premises will be initially presented on videotape.

Further factual information you may require can be obtained from the factory manager (ie, me). I will play the role of the factory manager.

Procedure

1 You are asked to watch a short videotape which shows a factory process. During the first viewing you should watch the tape without comment.

2 The tape may then be viewed again and you will have the videoplayer remote control, so that you can stop or navigate around the tape as you wish. You may ask questions here or seek clarification of scenes from the videotape.

3 Obtain further relevant information from the factory manager to establish all you need to know. You may continue with this questioning until you feel you have enough information.

Even when something appears obvious in the video tape please ask for empirical information for example using questions such as *can you tell me if.....?* or *can you confirm that...?*

Try to think of what you would want to find out if you were at the premises. Please ask confirmatory questions even where you are reasonably sure about the answer.

Please inform me when you feel you have enough information for your risk assessment and wish to terminate this part of the interview with the factory manager.

4 You will then have a short period of time to consolidate your risk assessment and recommendations on any necessary action and prepare a brief summary.

5 The factory manager will then ask some questions to establish the basis on which you have approached the exercise.

6 End of session.

14.7 APPENDIX SEVEN VIDEOTAPE CASE-STUDY: DETAILED DESCRIPTION OF VIDEOTAPE CONTENT

Information in brackets is not obtained visually from viewing the videotape but must be elicited by further questioning.

START OF VIDEO

1. A worker is rubbing a shiny surface with a rag (applying the silicone wax release agent to polish the mould pattern).

2. This is an old factory with apparently broken windows. There are various notices and a noticeboard attached to the right hand wall.

3. Another worker is holding plastic container carrying out close intricate work on a similar shiny surface (carrying out minor repairs to the mould pattern using and epoxy-filler).

4. Tools lying around various surface and there are tins (of paint) on the floor.

5. Working surfaces (mould patterns) are located on trestles.

6. Wires and various objects can be seen scattered on the floor of the factory.

7. Focus on a series of 45 gallon drums (which contain the styrene-based polyester resin and catalyst). These drums have no hazard warning labels although there is some writing/numbers as identification. The drums are of different colours. There are visible white deposits on the floor (resin) and similar deposits caked around the drum taps. There are some small inadequate spillage trays. One drum is separated and on its own on rack (contains the catalyst).

8. Pallets and various items scattered on the floor.

9. Paper on the noticeboard can be seen to be flapping indicating a draft.

10. A single blue fire extinguisher and a collection of brooms can be seen located near a door.

11. Worker rubbing a surface with a rag (polishing mould pattern as above)

12. A wooden roof with high lighting installations, skylights, and dirty broken windows can be seen.

13. Pallet stacks, with boxes (containing glass fibre rolls) apparently broken and apparently leaning over.

14. Two workers in the background painting (laying-up task - applying resin)

15. In the foreground a worker is rubbing a rag on a shiny surface with his bare hands. (polishing task as above)

16. A worker (carrying out mould pattern repair as above) is applying something to a shiny surface using a knife or small implement. Various tools are lying around.

17. Two workers:- one is putting sheeting (laying-up task - applying glass fibre sheet to mould) on to a surface and one is soaking the sheeting with a liquid (resin) which is being painted on. There is no hand protection visible. One worker apparently has his wrists taped up and is wearing overalls. The sheet can be seen to be fibrous. The other worker is not wearing overalls and has a tee-shirt.

18. A further worker can be seen bringing what looks like a cup of tea into the workshop.

19. Two workers, each with different types of overalls, can be seen in a corner. One is cutting up rolls of something (cutting glass fibre sheet task) with a knife whilst one is observing/assisting.

20. View of outside the showing neighbouring premises.

21. View of the wooden roof with dirty skylights showing former fan hole in end wall. Old fashioned high lighting can be seen.

22. Views showing untidy work stations, with (paint) tins on racks; articles (mould patterns) lying around; paint pots. Pallets in middle of the workarea, poorly stacked and broken.

23. View of (resin and catalyst) drums focusing on the spillage mess underneath and illustrating their position near the doorway.

24. Final view of a worker cleaning out a (resin) pot apparently with his bare hands.

END OF VIDEO

14.8 APPENDIX EIGHT VIDEOTAPE CASE-STUDY: RECRUITMENT OF PARTICIPANTS

UNIVERSITY OF
WOLVERHAMPTON

Dear Student

I have been approached by Chris Hartley from the Health and Safety Unit at Aston University. Chris is an occupational hygenist and is carrying out some research in the area of risk assessment and would like to enlist your help as an Occupational Health Nurse.

This will involve watching a video and answering some questions.

If you would be willing to help in this research, please return the tear off slip to Chris for more information.

Yours sincerely

Jackie Collins (Mrs)
Principal Lecturer

I would be willing to become involved in your research project, please send me more details.

Name .....

Title: .....

Work Address: .....

.....

.....

Phone No: .....

Please return to: Chris Hartley - Tutor
Health and Safety Unit
Aston University
BIRMINGHAM
B4 7ET

ASTON UNIVERSITY

June 27, 1994

Dear Occupational Physician

I am carrying out a researching risk assessment in health and safety professionals. Currently, I am seeking participants for this study. The experiment involves watching a videotape and participation in a short interview session. (The whole commitment would not be for more than one hour) The venue for the session would be wherever is most convenient for you. I provide feedback to participants on the findings of my research.

Previous participants have found the session interesting and useful.

If you are willing to become involved in this project I would be grateful if you would complete and return the tear-off slip (below). Alternatively please telephone me on (021 359 3611 text: 4444) and I will arrange a convenient time.

Yours faithfully

Chris Hartley

Chris Hartley

I would be willing to become involved in your research project, please send me more details.

Name: .....

Title: .....

Work address: .....

.....

Telephone number: .....

Please return to:

Chris Hartley
Health and Safety Unit
Aston University
Birmingham
B4 7ET

14.9 APPENDIX NINE VIDEOTAPE CASE-STUDY: BACKGROUND OF PARTICIPANTS

ASTON UNIVERSITY

BACKGROUND AND EXPERIENCE OF PARTICIPANTS

1. Introduction

In order to categorise the participants in this study it is necessary to have some basic details of background and experience details. Any information will obviously be confidential to this project.

2. Personal Details

Name:_____
Present Job Title:_____

3. Academic or professional qualifications

4. Work experience

Please give a very brief summary of your work experience, *ie.* industry, job title, responsibilities (if not self evident from job title) and approximate length of experience.

5. Membership of professional bodies

14.10 APPENDIX TEN VIDEOTAPE CASE-STUDY: SAMPLE CONSULTATION TRANSCRIPT FOR OCCUPATIONAL HYGIENIST

Sample Consultation Transcript and Classification

OH1 - occupational hygienist;
M - factory manager

OH1 What are they making?
M They are making glass-reinforced plastic doors.
OH1 What like house doors?
M Glass fibre, they are train doors
OH1 What is he doing there?
M Polishing up the mould starting moulding.
OH1 Using what?
M Using a silicone polish.
OH1 He is polishing up the mould and are there ever times when he has got to clean excess resin like that off the mould as well at the beginning?
OH1 Is that the only substance he uses to do that or does he have to use others
M Sometimes he does have to clean off the resin and he uses some chemical to do that.
OH1 Do you know what chemical that is? (to clean off excess resin)
M Acetone.
OH1 How many people are working in the area?
M Twelve people altogether.
OH1 What is this fellow doing?
M He is doing a bit of repair work, when the moulds get damaged...
OH1 How is he doing that I can't see (Obscured by the angle)
M We will come back to him a bit later.
OH1 There are electric cables all over the place - is that normal 240v?
M That must have happened today, we are not normally as bad as that. It is normal 240v.
OH1 What is in these drums?
M These drums contain the resins that we use, various resins.
OH1 Where do you get the resins from?
M From a local supplier.
OH1 Are they (resins) you have been using for a long time?
M Quite a long time.
OH1 Have you got any more detailed information about them? What are they called?
M Yes, I have got an industrial health and safety information sheet. (hazard data sheet produced here - subject comments that she has seen BIP data sheets before)
OH1 You just use several resins of a similar type? Polyester resins?

So do you just use this resin with the glass fibre sheet?

M Yes

OH1 Doesn't this have to be mixed with anything else?

M Yes it is mixed with an activating agent, a catalyst.

OH1 Do you know what that is?

M I do not have a data sheet on that (I am told it is an organic peroxide)

OH1 Where do you carry out the mixing? (Resin and catalyst)
Will we see that if we carry on with the video?

M No the men come up and take a sample of resin and .....

OH1 They open the tap and put it into a container?

M And take a small quantity of the catalyst.....

OH1 And is one of these drums the catalyst?

M Yes the drum which is just to the right of the mess room.

OH1 Do you have to weigh it out at all?

M They do it by eye.

OH1 So they take a quantity of the resins and a little bit of catalyst in a bucket?
How do they mix them together?
By hand or with some power tool?

M Just by hand.

OH1 And you say that when you mix them it gets hot?
Whilst you are walking around this place does it smell?

M Yes.

OH1 Quite a strong smell I would have thought!

M After a while you get used to it.

OH1 So you mix them together in a bucket and then what? (application of base resin) What happens next?

M First of all we apply a base resin to the mould, which is the same procedure, mix the resin and catalyst.

OH1 Is that the same type of thing then? (broadly - but some differences)

M I am told it is with similar materials but some differences.

OH1 In what way do they differ?

M I am not sure. Its to lay the base of the mould.

OH1 Do you paint that on the mould by hand?

M Yes.

OH1 So the mould is first polished by silicone polish?

M Yes

OH1 Then you paint the base coat of resin on by hand?
Is that what they are doing there? (in the video)

M I think they may be a painting on the mould resin. The base resin is just painted on to the actual mould itself. (After the mould release agent to ensure it does not stick)

OH1 So you have got the mould, you polish it with silicone polish, do you spray it with a release agent?

Do you know what that is?

M No

OH1 Have you got any data on the release agent? (PVA)

M PVA something like that.

OH1 Does that smell?

M No

OH1 When you spray it on it is a liquid and then how long does it take to dry?

M It is sprayed on then quickly rubbed over and dries very quickly.

OH1 You just use a bit?

OK you put that on, and then you paint on your first coat of base resin?

What happens when it cures?

Does it get warm when it is curing?

Or does it just sit there and gradually go hard?

M It gradually just hardens. After about an hour then you apply the mould resin. This is basically the same as the other.

OH1 Is the mould resin the stuff that was in the drums that we looked at first?

M Yes.

OH1 Do you use larger quantities of the mould resin?

M Yes

OH1 Can you describe how you would apply that? (the mould resin) That's glass fibre.

How many layers would you do like this?

M Three layers.

OH1 So you would do one layer and immediately start applying the next layer or would you wait?

M You would wait a little while for it to dry out.

OH1 And how long does all this take?

M Cleaning of the mould up to an hour, mixing few minutes, curing time.

OH1 How long do you think it would take to apply the three layers of mould resin and fibre glass?

M Probably about four hour – with each layer you want to get the air bubbles out. So you are tapping the mould.

OH1 Does that include the waiting time between layers?

M Yes.

OH1 I think I have missed a bit there, lets come back a bit. When you have got the mould resin applied the top surface is still pretty rough?

Two blokes working on one mould?

M Yes they work in pairs.

OH1 Have you got any gloves?

M I must check with the foreman.

OH1 What is he doing here? (cutting glass fibre)

M He is cutting up the glass fibre sheet.

OH1 Does he do that all day? (cutting glass fibre)

M No they are both moulders, the fellow in the white overall is a new recruit. But I do like them all to be moulders so that they can all do the same work.

OH1 Each moulder can cut their own fibre glass sheet? So they switch jobs and take it in turns?

But on a particular day one person may cut it up for everybody else?

M Someone would not be doing that all day.

OH1 But someone would not be doing that all day?

When we have got the three layers on what happens next?

What happens here? (looking out from the door of the factory)

M That is looking out of the door of the factory into the local environment.

OH1 It is a very high roof? (the factory's)

M It is quite high.

OH1 No evidence of any fans or general ventilation?

M They do have the door open.

OH1 There are not any mechanical ventilation systems installed?

M No.

OH1 Are they just clear panels in the roof they are not opening windows?

M No.

OH1 There is plenty of light?

M Not too bad for an old building.

OH1 I bet it is pretty difficult to heat in the Winter?

M Yes.

OH1 I bet it gets quite warm in the Summer?

M Yes.

OH1 So in the process we have got these three layers of resin and fibre glass on, so what happens next? Is there anything else done to it?

M It is allowed to cure overnight or in the daytime and then it is taken to another work area and an operator with a hand grinder finishes it off.

OH1 Which surface are we talking about here - the surface that has been in contact with the mould or the top surface?

Have we taken it off the mould yet?

M Yes.

OH1 Is it easy to get it off the mould or do you have to have to do anything to it?

M It usually comes off quite easily. It is levered off.

OH1 So it is taken off the mould and taken to another workarea?

M Then we have someone who is full-time on the job smoothing off the surfaces.

OH1 Using what (tool) did you say?

M A portable grinder.

OH1 A power tool?

Like an orbital sander - something like that?

M Yes.

OH1 Is that electric or compressed air?

M Electric.

OH1 Can I see that?

M No.

OH1 What is in those big packing cases there?

M They are rolls of glass fibre. You can see we are a bit limited for storage space.

OH1 So you have got those drums that are on their sides for dispensing - have we seen where you keep your other drums - the ones that are waiting to be used?

M These are all the drums we have at one time.

OH1 You have none stacked up waiting to be used?

There is one there for example - so that is about it?

Have you ever actively sought out any information on health and safety?

Have you ever had any consultants in to do any measurements of fumes or solvents?

M We have never had any problems as far as I know.

OH1 How long have you been operating?

M I have been here about three years.

OH1 What about your workforce - are they quite a stable workforce or have you got much turnover?

M We have quite a bit of turnover.

OH1 Why do you think that is? (high turnover)

M Probably, they would say we do not pay enough.

I have got a good idea about the process now; I have a good idea about what I think are the hazards of the process and the risks.

OH1 Am I right in thinking that your people are doing the same thing all day and every day?

M Yes.

OH1 I would suspect there is a problem. I would guess there is a pretty strong smell of solvent (styrene). You would need to control people's exposure to that. It may be that you would need to provide some sort of ventilation to prevent people being exposed. (M Why?) If you are overexposed to solvents it can have short-term health effects, it might, people might end up having headaches at the end of the day, but they might put it down to something else, so they wouldn't necessarily complain to you. It would have long term effects – so you could be storing up trouble for yourself and your workforce for the future that are not going to be immediately obvious. You might have a problem

that you are not aware of yet. So yes I think that you may have a problem. (M If we do not know if we have a problem - how do you know that our people might be overexposed?) You can measure the concentrations of sample vapours in air and there are published standards that you can compare that to – they are called occupational exposure limits. You can measure somebody's average exposure over the day and compare it to the exposure limits. I think that you might be approaching it if not exceeding it.

You may be exceeding the limit:

- because of the quantity of the resin you are using
- used by people manually (over four hours)
- apply themselves and are having to lean over the moulds all the time they are applying it
- long periods leaning over it when the solvents is evaporating into people's faces

They will be getting a fair exposure. It is difficult to control though for a job like this because they do need to lean over it all the time. I think you need to check what their exposure is (measure on a few people) Styrene is quite volatile and it will evaporate past people's faces.

Nature of the solvent, the length of time they are using it, the amount you use and that they are doing it all day every day.

Measure it. Depending on the exposure measurements – (need a consultant to do that, staff would have to wear a sampling device). If above (Control is a tricky thing – short-term PPE face mask either charcoal filter device/ half mask that would take the solvent vapours out, over their nose and mouth; (people would not like wearing those) if a long way over the limit (2x - 3x) you would need to look at a more permanent solution such as Local Exhaust Ventilation.

But this LEV is difficult to design for the type of work you are doing.

Firstly - measure and see what the results are. That the solvent vapour issue dealt with.

Another issue, next you do not want resins on their skin

Are you aware of you employees ever having any skin problems?

M No

OH1 How do they clean resin off their skin? (acetone)

M They probably use the acetone.

OH1 May have high exposure to acetone although I guess they do not use as much of that and it is not a regular occurrence. Using acetone to clean resin off people's skin is not a good practice. People may get dermatitis. You should get some better gloves; some barrier cream and some cleansing agent to help with skin protection.

Another issue glass fibre - handling without gloves that will give you very itchy skin - need gloves (probably the same gloves will do; it is more critical with the solvent)

M One or two have complained about that.

OH1 Is handling the GF a very dusty operation?

M Not very dusty.

OH1 GF sheet is normally quite thick fibres. So it is probably not going to be a big dust problem. Smoothing - is that a dusty process?

M Yes that is a dusty process. The fellow that does that we have got him a helmet.

OH1 What sort of a helmet (airstream)

M Its a helmet that sucks air through it with a visor. So he breathes in clean air. Its quite expensive.

OH1 Has that got some battery pack on it with filter?

M Yes.

OH1 And do you change the filters?

M Yes, he is the only person who does that work and he has been trained to use it and he is entirely responsible for it.

OH1 And has he got a supply of fresh filters?

M Yes, I should hope he has.

OH1. You will need to keep changing the filter

What about the orbital sander has that got an extractor bag on it?

M No, I do not think so.

OH1 The next time you change your sanding unit get one with an extractor bag on it I would suggest.

Is the sanding a noisy process?

M Quite noisy.

OH1 How long does he spend doing that?

M The whole day.

OH1 Do you think it is not noisy?

If he was doing that and you went up to speak to him would you have to shout?

M You probably would have to wait until he had stopped.

OH1 He is probably close to or over the exposure limit for noise if he is doing it all day.

You have never had the noise measured have you? You could either get it measured or just buy some of those disposable ear plugs for him to use.

From seeing processes like that before – it is probably not even worth measuring - I would get some of those disposable ear plugs for him to wear.

In the Noise Regulations there are two limits (an average over the day) I am sure you would be above the 85 limit (and you must offer him hearing protection); you may be over the 90 (He must wear the protection or you must reduce levels by some other means.)

Plugs because it is difficult to wear muffs with a helmet.

With orbital sanding all day – other thing is vibration on his hands. Is it warm in that shop?

M No, not very warm.

OH1 And cold in the Winter?

M Yes

OH1 If someone is using a vibrating tool all day especially if it is cold, they could end up having vibration damage to their fingers. Again it is difficult to control. Control by buying a vibration damped tool and wearing gloves to keep his hands warm. Next time you replace it – look for a low vibration tool with a dust extractor. In terms of health risks, I think we have dealt with the main ones.

Most important: – styrene solvent exposure - lot of people and all the time each day – affects everyone and used continually, large quantities.

Health and Safety?

Congested workarea and poor storage, separate storage area needed.

Trailing cable - tripping hazards and electrical safety, cables fray and mains voltage and the resins are all flammable. I cannot remember the legislation on keeping flammable liquids in a flameproof store. You may need a flameproof store - flashpoint below 32.

SAMPLE ANALYSIS OF TRANSCRIPT CONTENT USING CLASSIFICATION

BUILDING

MOULDING PROCESS

What are they making?

What like house doors?

You just use several resins of a similar type? Polyester resins?

So do you just use this resin with the glass fibre sheet?

Whilst you are walking around this place does it smell?

Quite a strong smell I would have thought?

Is the mould resin the stuff that was in the drums that we looked at first?

Do you use larger quantities of the mould resin?

PREPARATION

What is he doing there? (Polishing the mould)

Using what?

He is polishing up the mould and are there ever times when he has got to clean excess resin like that off the mould as well at the beginning?

Is that the only substance he uses to do that or does he have to use others

Do you know what chemical that is? (to clean off excess resin)

So the mould is first polished by silicone polish?

So the mould is first polished by silicone polish?

Then you paint the base coat of resin on by hand?

Is that what they are doing there? (in the video) (mention of mould release agent)

So you have got the mould you polish it with silicone polish, do you spray it with a release agent?

Do you know what that is?

Have you got any data on the release agent? (PVA)

Does that smell?

When you spray it on it is a liquid and then how long does it take to dry?

You just use a bit?

OK you put that on and then you paint on your first coat of base resin?

ACTIVATING RESIN

Doesn't this have to be mixed with anything else? (Catalyst)

Do you know what that is? (Catalyst - organic peroxide)

Where do you carry out the mixing? (Resin and catalyst)

Will we see that if we carry on with the video?

They open the tap and put it into a container?

And is one of these drums the catalyst?

Do you have to weigh it out at all?

So they take a quantity of the resins and a little bit of catalyst in a bucket?

How do they mix them together?

By hand or with some power tool?

And you say that when you mix them it gets hot?

CUTTING GF

What is he doing here? (cutting glass fibre)

Does he do that all day? (cutting glass fibre)

So they switch jobs and take it in turns?

But on a particular day one person may cut it up for everybody else?

But someone would not be doing that all day?

LAYING-UP

So you mix them together and then what? (application of base resin)

Is that the same type of thing then? (broadly - but some differences)

In what way do they differ?

Do you paint that on the mould by hand?

OK you put that on and then you paint on your first coat of base resin?

Can you describe how you would apply that? (the mould resin)

How many layers would you do like this?

So you would do one layer and immediately start applying the next layer or would you wait?

And how long does all this take?

How long do you think it would take to apply the three layers of mould resin and fibre glass?

Does that include the waiting time?

When you have got the mould resin applied the top surface is still pretty rough?

Two blokes working on one mould?

Have you got any gloves?

CURING

What happens when it cures?

Does it get warm when it is curing?

Or does it just sit there and gradually go hard?

FINISHING

When we have got the three layers on what happens next?

So in the process we have got these three layers of resin and fibre glass on, so what happens next? Is there anything else done to it?

Which surface are we talking about here - the surface that has been in contact with the mould or the top surface?

Have we taken it off the mould yet?

Is it easy to get it off the mould or do you have to have to do anything to it?

So it is taken off the mould and taken to another workarea?

Using what (tool) did you say?

A power tool?

Like an orbital sander - something like that?
Is that electric or compressed air?
Can I see that?
Is handling the GF a very dusty operation?
Smoothing - is that a dusty process?
What sort of a helmet (airstream)
Has that got some battery pack on it with filter?
And do you change the filters?
And has he got a supply of fresh filters?
You will need to keep changing the filter
What about the orbital sander has that got an extractor bag on it?
The next time you change your sanding unit get one with an extractor bag on it I would suggest

REPAIR

What is this fellow doing? (Repairing the mould)
How is he doing that I can't see

STORAGE/HANDLING

What is in these drums?
Where do you get the resins from?
What is in these drums?
Where do you get the resins from?
Are they (resins) you have been using for a long time?
Have you got any more detailed information about them?
What are they called?
What is in those big packing cases there?
So you have got those drums that are on their sides for dispensing - have we seen where you keep your other drums - the ones that are waiting to be used?
You have none stacked up waiting to be used?
There is one there for example - so that is about it?

CHEMICAL HAZARDS

GENERAL WORKPLACE HAZARDS

There are electric cables all over the place - is that normal 240v?
Other thing is vibration on his hands?
Is it warm in that shop?
And cold in the Winter?
Control by buying a vibration damped tool and wearing gloves to keep his hands warm.

FIRE

NOISE

Is the sanding a noise process?
How long does he spend doing that?
Do you think it is not noisy?

If he was doing that and you went up to speak to him would you have to shout?

He is probably close to or over the exposure limit for noise.

You have never had the noise measured have you?

You could either get it measured or just buy some of those disposable ear plugs for him to use.

It is probably not even worth measuring - I would get some of those disposable ear plugs for him to wear.

I am sure you would be above the 85 limit; you may be over the 90.

Plug because it is difficult to wear muffs with a helmet.

LIGHTING

There is plenty of light?

WORKFORCE

What about your workforce - are they quite a stable workforce or have you got much turnover?

Why do you think that is? (high turnover)

HEALTH EFFECTS

Are you aware of you employees ever having any skin problems?

How do they clean resin off their skin? (acetone)

PATTERN OF WORK

Am I right in thinking that your people are doing the same thing all day and every day?

NUMBERS

How many people are working in the area?

CURRENT CONTROL MEASURES

VENTILATION

It is a very high roof? (the factory's)

No evidence of any fans or general ventilation?

There are not any mechanical ventilation systems installed?

Are they just clear panels in the roof they are not opening windows?

PPE

Have you got any gloves?

EYE WASH

HOUSEKEEPING

STORAGE & HANDLING

HEALTH SURVEILLANCE

FIRST AID

RISK ASSESSMENT

You have never had the noise measured have you?

SUBSTANCE INVENTORY

HAZARD DATA SHEETS

AIR MONITORING

Have you ever had any consultants in to do any measurements of fumes or solvents?

TRAINING/INFORMATION

SPILLAGE PROCEDURE

WASTE DISPOSAL

FIRE PRECAUTIONS

WELFARE

MAINTENANCE

HSE INSPECTIONS

GENERAL MANAGEMENT

Have you ever actively sought out any information on health and safety?

HEALTH AND SAFETY ORGANISATION

WORKSHOP MANAGER

Have you ever actively sought out any information on health and safety?

OTHER CONTROLS

MISCELLANEOUS

Are they (resins) you have been using for a long time?

How long have you been operating?

CONCLUSIONS

Comments on problems:

Need to control people's exposure to styrene

You may need to provide some ventilation to prevent exposure of people

You may be exceeding the limit:

because of the quantity of the resin you are using

used by people manually

apply themselves and are having to lean over the moulds all the time they are applying it

long periods leaning over it when the solvents is evaporating into people's faces

It is difficult to control though for a job like this because they do need to lean over it all the time

Next you do not want resins on their skin

May have high exposure to acetone although I guess they do not use as much of that and it is not a regular occurrence

Using acetone to clean resin off people's skin is not a good practice

People may get dermatitis

RECOMMENDATION

VENTILATION

I think you need to check what their exposure is ((measure on a few people)

Styrene is quite volatile and it will evaporate past people's faces

Depending on the exposure measurements –

If above – short-term PPE face mask either charcoal filter device/ half mask over their nose and mouth; if a long way over the limit you would need to look at a more permanent solution such a LEV

But this LEV is difficult to design for the type of work you are doing

PPE

I think you need to check what their exposure is ((measure on a few people)

Styrene is quite volatile and it will evaporate past people's faces

Depending on the exposure measurements –

If above – short-term PPE face mask either charcoal filter device/ half mask over their nose and mouth; if a long way over the limit you would need to look at a more permanent solution such a LEV

But this LEV is difficult to design for the type of work you are doing

You should get some better gloves; some barrier cream and some cleansing agent to help with skin protection.

Glass fibre - handling without gloves that will give you very itchy skin - need gloves (probably the same gloves will do; it is more critical with the solvent)

EYE WASH

HOUSEKEEPING

STORAGE/HANDLING

HEALTH SURVEILLANCE

FIRST AID

RISK ASSESSMENT

You could either get it measured or just buy some of those disposable ear plugs for him to use.

SUBSTANCE INVENTORY

HAZARD DATA SHEETS

AIR MONITORING

I think you need to check what their exposure is ((measure on a few people)

Styrene is quite volatile and it will evaporate past people's faces

Depending on the exposure measurements –

If above – short-term PPE face mask either charcoal filter device/ half mask over their nose and mouth; if a long way over the limit you would need to look at a more permanent solution such a LEV

But this LEV is difficult to design for the type of work you are doing

TRAINING/INFORMATION

SPILLAGE PROCEDURE

WASTE DISPOSAL

FIRE PRECAUTIONS

WELFARE

MAINTENANCE

GENERAL MANAGEMENT

HS ORGANISATION

WORKSHOP MANAGER

MISCELLANEOUS

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